

# CONTENTS

**Air War in Western Europe . . . . . 3**

**Museum Map . . . . . 16**

**The Exhibitions . . . . . 17**

    Welcome Desk . . . . . 19

    Info Room . . . . . 20

    Hanger . . . . . 20

    War Room . . . . . 21

**Jane’s WW II Fighters Museum Collection . . . . . 22**

    Other Aircraft on the Western Front . . . . . 41

**Basics of Flight . . . . . 52**

    Physics . . . . . 52

    Movement Vectors . . . . . 54

    Control Surfaces . . . . . 55

    Basic Flight Maneuvers . . . . . 57

**Combat . . . . . 61**

    Air-to-Air Combat . . . . . 62

    Air-to-Ground Combat . . . . . 86

**Credits . . . . . 90**

# AIR WAR

## *in Western Europe*

### AIR WAR COMES OF AGE

In the First World War, air power emerged as a dramatic new dimension of combat. German dirigibles had bombed London, causing panic. Biplanes and triplanes soared, locked in dogfights over the trenches of France. The men flying the fragile airplanes cut a romantic figure as they rose into the sky. In an era full of fear at the regimentation and mass movement of man, they were a welcome throwback to the knights of old, charging into enemy lines either single-handedly or in small squadrons. Among even the most bitter opponents, there was an almost medieval code of chivalry. Aces such as Baron Manfred von Richthofen (the legendary Red Baron) and his successor Hermann Goering became worldwide celebrities.



Urban devastation: the dream of Douhet and other prophets of air power.

While capturing the imagination, these initial air ventures had little effect on the course of the war. Soon after the conflict ended, however, hints of the future began to emerge. Stronger engines and better designs made new strategies possible. The planes became bigger and faster, and were able to carry heavier loads. The implications of these advances were set forth with chilling vision by Italian Giulio Douhet, in his 1921 book *Command of the Air*. He declared the era of ground war over; from now on war could be fought and won in the air. Douhet proposed huge flying bombers that could penetrate far behind lines of battle—bypassing the trench warfare that had slowly eaten the morale of First World War armies—and pulverize enemy cities. The resulting panic and destruction would demoralize one's opponent and bring any war to a speedy conclusion.

British and American designers read Douhet's theories closely. Both began designing large, long-range bombers with the intent, should war come, of taking combat deep inside enemy lines. Both met strong internal resistance to such a strategy: the thought of slaughtering huge numbers of civilians was repugnant to the leadership, especially the American government of Roosevelt. It would be an ironic twist that those most reluctant would be the ones most successful at wholesale urban destruction, culminating in the atomic annihilation of Hiroshima and Nagasaki.

Equally ironic was that those who would goad the Allies into such devastation never put much stock in Douhet's book. Germany's rebuilt air power concentrated on the bomber as battlefield support, and their planes were accordingly smaller and with much shorter range. In the initial sweep of war, this would be highly successful. When the time came for attempts at behind-the-lines civilian assault, those most eager to decimate populations would find their air power poorly equipped to help in the project.

### AIR POWER AND THE SECOND WORLD WAR



A vast Allied bomber armada heads for Hitler's Reich.

As the Second World War progressed, the theories of Douhet and another early champion of air combat potential, American William "Billy" Mitchell, would be tested to their utmost. Some ideas proved accurate; others had results far different than those envisioned. Douhet's belief that urban bombing would demoralize a nation proved quite incorrect when Germany attempted to level British cities in the Battle of Britain. In fact, it united the British people and hardened their resolve to see the war through to its conclusion. Oddly enough, the British leadership failed to learn its own lesson and followed the exhortations of another air power devotee, Arthur "Bomber" Harris, perhaps the war's most zealous advocate of massive civilian bombing. He was convinced that the German people, unlike his own island's residents, would crumble and blame their leaders for disaster if subjected to horrific raids. While the economic and strategic results of the massive Allied bombing effort can be argued, the German civilians, like their British counterparts, simply dug in and endured.

If civil collapse was not achieved, Britain alone could not accomplish the other goals of large-scale bombing. It took the entry of the United States into the war for the two nations to combine efforts and strategies and impact the German military machine in a decisive manner. Britain favored night time raids; America confidently chose daylight. Together this round-the-clock bombing strategy aimed to pummel German industry into the ground, and force the Luftwaffe into a defensive position, thus depriving German forces on the front lines of air support.

A burden to bombing strategy was the distance which the planes had to travel. Though equipped with some gun turrets, the bombers were easy targets for fast-moving fighter planes which rose to meet the attack. For raids along the nearby fringes of enemy territory, friendly fighters could fly as escort to the larger planes and fly out to engage enemy fighters. As Allied raids aimed deeper and deeper into German territory, however, the fuel capacity of their fighters forced the tiny planes to turn back often well before the bombers were over their prime targets. Left on their own, the bomber losses were staggering. Champions of heavy bombing such as Harris and American General Carl Spaatz found themselves hard-pressed to justify the losses against the questionable levels of damage inflicted to German military potential.

One result of the Allied bombing offensive that was an unqualified success was its effect on the Luftwaffe. At a time when the tides of battle were turning against Germany, an air force designed for offense and ground support in the field of battle was instead forced to stay on home turf and defend industry and urban sites against an ever-growing enemy swarm. The attrition rate for Allied flyers was horrifying, but the sheer manpower available to the Allies meant losses could be replaced. Germany's losses were crippling. Skilled pilots were replaced by men who, due to time constraints and scarcity of fuel, had little training. No matter what "miracle weapons" Hitler's weaponers might design, the skills of those flying them ensured the impact of those wonders would be minimal.

## **AIR WAR: 1943-44**

All across the western front in 1943, air power was playing a critical role. The early mistake Hermann Goering, architect of German air power, made in emphasizing smaller bombers for troop support was now apparent as the four-engine long range bombers of the Allies roared over Germany. At the war's start, it was the Luftwaffe inspiring terror while screaming over foreign skies. Now, over its own territory, Goering's air force fought a desperate battle with an enemy growing in strength and confidence.

In late 1942, the Allies escalated saturation bombing to round-the-clock bombing. The British would fly over German cities by night and do their best to utterly destroy them. By day, American bombers would attempt to pinpoint more strategic targets and cripple German industry. American faith in its bombing sights was misplaced, however: the height their planes had to fly to avoid anti-aircraft artillery often negated any accuracy those sights might provide. Bombs often fell miles from their target.



An American Liberator succumbs to German air defenses.

In summer 1943 the Allies bombed Hamburg for four consecutive nights, taking 40,000 lives and creating a huge firestorm. The citizens—those who survived—were stunned and numbed, but did not turn on their leaders. In August, American planes from Libyan bases reached Ploesti, Romania's huge oil facility. As they flew over the Balkans, wave after wave of Luftwaffe fighters rose and hammered them. A quarter of the men on the mission died. Slightly more than one-sixth of the planes survived or were able to be flown again. The facilities were soon repaired and operational.

For both sides, losses were terrible. The Luftwaffe were losing pilots at a speed too great to replace. By late 1943, most planes rising to meet the huge fleets of Allied bombers with their swarms of fighter support were piloted by men with much less training, let alone battle experience. As for the Allies, their fighter planes could not make the longer journeys to support the bombers. As better fighters were built and their range increased, more German targets could be reached, but at a certain point, they had to turn back—and then the Luftwaffe and its speedy planes could tear the bombers to pieces. It would not be until 1944 that additional gas tanks called 'drop tanks' would enable Allied fighters such as the P-51 Mustang to penetrate deep into Nazi territory and destroy the Luftwaffe.

Equally dreaded was the 88 mm antiaircraft gun. Closely concentrated, dug in near vital industrial areas and other targets sure to attract Allied air raids, Flak guns may have taken out more bombers than the Luftwaffe throughout the course of the war.

Amazingly, though fuel and pilots were scarce, fighter production continued to rise in Germany. Hitler's new minister of production, Albert Speer, had reorganized the economy and cut as best he could through the multiple layers of squabbling bureaucracies to actually increase all-around military production. This in the face of round-the-clock bombing raises questions as to the strategic, as opposed to propagandistic, value of the constant raids.

One definite result of round-the-clock bombing was that the Luftwaffe was being slowly bled dry. While not destroying German industry, the bombing strategy had pinned Goering's forces down on the home front. While more planes were being built, they couldn't keep pace with the losses sustained against the Allies. Hitler began putting more and more hope—and more and more resources—into a host of experimental weapons he believed would turn the tide again to his favor. Goering, desperate to regain favor, encouraged his Führer in those dreams. And in the East, the loss of air support to defense over Germany left the Wehrmacht open to the grinding, inexorable advance of the Red Army.

## COUNTDOWN TO INVASION

By now the path of the war had become plain, like a hideous ballet whose choreography had been planned and now must be followed through. German High Command knew that eventually the Western Allies were going to strike across the English Channel and fortifications were accordingly built. Generalfeldmarschall Erwin Rommel, considered one of Germany's best generals, was brought north from overseeing the occupation of what was left of Mussolini's regime to supervise the anticipated defense of the beaches. He immediately began construction of an elaborate series of defenses. If invasion came, he thought, and the Allies could be repelled on the beaches, it would be years before they could muster another assault.



B-17s unload their "sticks" on the target.

Hitler too hoped for a decisive blow on the beaches. In the face of the crushing defeats being dealt the Wehrmacht in the East, he was still convinced he could triumph over his enemies. He moved many of his best divisions to France and the Low Countries to wait for the invaders and smash them on the beaches. From there, holding them in the Italian bottleneck would be easy. Full force could be concentrated on the Soviets, who would then crumble. Hitler could then choose the time and place for his victorious attack against the West.

Unfortunately for the Führer, his visions of destiny combined poorly with faulty Nazi intelligence gathering. Allied diversions led German High Command to grossly overestimate the size of the invasion force gathering in England. Thus, more German divisions were held down in France, just as the Red Army was hitting high gear in its most brutal offensives yet. Further Allied deception tricked Rommel into positioning most of the finest armor and best troops far away from the actual landing point. As newly-appointed Supreme Allied Commander Dwight D. Eisenhower polished plans for a Normandy landing, the best Germany could throw against an attacker was waiting to the east, convinced the Allies would make a straight line from Dover to Pas de Calais. Any landings to the west, thought Rommel, were diversionary attacks to be disregarded and dealt with later.

Meanwhile, Allied round-the-clock bombing continued its relentless pounding of the German landscape. The Luftwaffe was slowly being whittled away. Though Albert Speer was achieving sinister miracles in keeping armaments production high, damage to transportation infrastructure and the massive consumption of fuel by units engaged to the south and east meant that poorly trained pilots were rising to meet Allied flyers. The few skilled German pilots left were busy testing the secret weapons Hitler was always boasting of, the weapons that in his wild inner world would turn the tide of war. Allied bombs had hindered development of his V-2, the world's first rocket weapon, with which he hoped to bring the Blitz back to London. With their debut put off by a year, the Führer instead demanded a renewed conventional bombing assault on England at the start of 1944. The Luftwaffe thus squandered precious planes on a futile "Baby Blitz", as Londoners called it. Until May 1944, a force of 500 bombers inflicted minimal damage as Allied air defenses blasted more than half of them out of the sky.

In the East, the Red Army continued slowly steamrolling over the Wehrmacht. Their 1943–44 winter offensive gave the Germans no rest. By spring 1944, Germany was in full retreat in the East. The Soviets had their choice of where to strike first. Reinforcements poured into the Red Army; its Ural industrial base, untouched by Axis assault, sent a steady stream of weaponry toward the front. The Germans in the East, on the other hand, were increasingly desperate. Reinforcements and new weaponry were being sent westward, to guard the beaches of France. Partisans roamed behind the lines freely, pinning down Nazi troops, destroying supply lines

and communications. Years of slaughtering Soviet officers and starving prisoners of war had made their enemy a merciless, furious foe. No German wanted to be taken prisoner by the Red Army. It was a virtual death sentence.

In Italy, the first of the Axis nations to be invaded, the Allies saw a much slower advance. Given terrain, climate, and the proximity to the Reich itself, the German defense was more tenacious, despite the Italian populace's eager embrace of the Allied assault. The fighting was slow, torturous, and bloody, with only more devastation likely as the Allies would slug their way up the narrow peninsula. But as Italy and her liberators looked ahead, the only thing that could shorten the bloodshed was on the horizon: the attack from the west. The time had come at last for D-Day.

## **D-DAY**



Gliders carrying troops into Normandy.

Operation Overlord, the largest amphibious assault ever undertaken, began on June 5, 1944, during a break in an unexpected storm which nearly forced Supreme Allied Commander Dwight D. Eisenhower to call off the invasion. Due to amazingly successful Allied deception as well as the bureaucratic stupidities and inept intelligence-gathering of the Germans, the landings were a surprise.

Massive air power had been called in. For weeks, bombing runs had been softening up the coastal defenses, and surveillance flights had pinpointed the major installations. Even Arthur "Bomber" Harris put aside his usual obsession with terror bombing and committed his forces to aiding the invasion, devastating the rail lines and infrastructure Germany needed if it was to respond quickly to the assault. Allied fighters and bombers ruled the skies: the Luftwaffe's ill-advised "Baby Blitz" had left it even weaker than it already was, and the landing sites were all within range of fighters based in England.

The Germans were taken in by almost every Allied diversion. Dummy parachutists convinced Rommel that his instincts were correct: the forces landing at Normandy were simply a diversionary attack. He refused to be fooled; his main forces, including prized panzer divisions which might have blown the landing troops to pieces, remained to the east, and would stay there for crucial days to come. Surely the main landing would come at one of the strategic harbors the Germans held, and had built impenetrable defenses around. What Rommel didn't know was that the Allies had built two floating harbors of their own, and that these huge devices were on their way across the channel.



American Thunderbolts meet French livestock on a temporary runway.

The key to victory was landing as many forces as fast as possible, and the Allies succeeded brilliantly. Before the Germans realized the main invasion really was happening and could get reinforcements to contain the beachheads, the floating harbors had unloaded artillery, armor, and thousands of men. Even a terrific storm's destruction of one of the artificial harbors on June 19 couldn't help the Germans. The first day's hesitations cost them the battle. Their numerical superiority in troops and armor was too slowly deployed, and their air defenses had been shattered by wave after wave of Allied planes.

Still, the destruction was terrible. The defenders gave ground grudgingly, fighting field by field, inflicting heavy losses on Americans in the west and the British further east. But after bitter initial fighting, by the 14th the Americans, under the colorful General George Patton, had broken through German lines and drove toward Cherbourg, which fell on the 26th. The Allies now had a true harbor through which they could pour weaponry and supplies. The Nazis had done their best to destroy the city and its harbor, but within three weeks Cherbourg was beginning to unload further invasion forces.

The Allies had firmly established themselves on the continent, though progress was slower than initially anticipated. Field Marshal Bernard Montgomery, the hero of El Alamein, the crucial battle which turned the tide against Germany in North Africa, was unwilling to take the heavy losses a major British push would entail. The Americans to the west found themselves in terrain which hindered the advance of their heavy armor. Once they attached gigantic spikes to the front of their tanks, however, they could go off road again, punching through the hedgerows of northern France and into the face of the ferociously-resisting Germans.

As American armor hammered in the west, to their east, Nazi armor was doing its best to push the British back to the beaches. But from the air came swarms of Allied fighters and bombers, pinning the tanks in their positions, making movement slow and deadly. Round-the-clock air attacks from Allied planes and futile offensives had left the Luftwaffe, in the hour it was most needed, outnumbered and outgunned.

From Berlin, Hitler made a confusing situation worse, issuing contradictory orders, berating, ignoring, and overruling his generals. He refused calls for a counterattack against the menacing American armor which threatened to buckle the entire defensive line in France. He didn't want to risk the army; instead it began to be whittled and chipped away as it was slowly pushed back, with no reserves to replace the losses.

Meanwhile, his fervent belief in his secret weapons program finally bore fruit in mid-June. The first V-1's, pilotless jet planes loaded with explosives, began falling on London. Although the appearance of these odd bombs were a blow to British morale—Churchill even demanded retaliatory poison gas attacks, but was overruled by the Americans—actual damage was nowhere near as great as Hitler envisioned. The V-1's were easily shot down, and many others missed their London target. Panic did not set in; London was not evacuated; the Allied war effort continued unhindered. Once again Douhet's predictions failed to come true. The weapons designed to suddenly win the war only hurried the Allies to break out of the Normandy beach heads to reach the V-1 launch sites.

Nazi generals finally got the hint that Normandy was, indeed, the big landing by late July and began moving their long-sidelined armor from Pas de Calais to intercept American tanks. By then the difficult terrain was behind Patton's forces, however, and open country well-suited for armor was now before the audacious general. Hitler finally agreed to a counterattack at Mortain, and issued orders to strike—orders which were intercepted and decoded by the Allies, who had broken almost all the German codes and knew exactly when and where the attack was to come. Allied air power, combined effectively with the ground troops, stopped the assault in its tracks. As the Americans pummeled their attackers, the British and Canadians previously pinned down by those German troops moved south. Had Montgomery not once again been too cautious and held back his best

troops, the Germans would have been trapped and annihilated in another Stalingrad. As it was, many of them escaped, although with huge losses in life and equipment. By late August, the British were clearing Belgium and capturing the V-1 launch sites, and to the south, defying Hitler's orders to level the city, Gen. von Choltitz pulled out of Paris. On August 25, advancing American troops held back and let Charles de Gaulle's Free French forces liberate their long-suffering capital. Ten days earlier, more Allied troops had struck from the south, landing on the French Mediterranean coast. Churchill had heatedly opposed this operation, pushing instead for continued pressure in Italy. Given the choice of advancing slowly to an Alps range filled with Nazis armed to the teeth or seizing the ports of Marseilles and Toulon, Eisenhower understandably overruled the British prime minister's strategy.

The German lines were crumbling. From the Low Countries to the Swiss frontier, Allied troops were racing toward the borders of the Reich. Hitler grudgingly allowed the troops in the south of France to pull back and avoid encirclement. Almost all of France had been taken in two months' fighting. With the Nazi armies went the wartime French government based in Vichy. Coming to power through French defeat, they now faced disaster of their own as France was freed, having tied themselves to the fate of their conquerors. From southwest Germany, they watched as the Wehrmacht abandoned France and regrouped along the border, holding as many Low Country ports as it could.

That holding of ports became ever more troublesome for the Allies as 1944 progressed. While Cherbourg was slowly being cleared, other liberated ports such as Brest had been so badly wrecked by the retreating Germans that they were unusable. As Germany's supply lines shortened, lessening the strain on its battered infrastructure, the Allied lines stretched forward, with huge levels of troops, planes, tanks, and artillery to maintain. The damage they had done to infrastructure to cripple Nazi supply lines now haunted them. The only thing that helped them get as far as they did before supply became a major issue was the valiant drivers of a massive convoy of trucks laden with fuel and weapons which came to be called the Red Ball Express. A round-the-clock substitute for the ruined rails ran nearly 90,000 tons of supplies from the landing beaches of Normandy deep into France in the space of a few weeks.

By the time the Allies were closing in on the Reich, even that fuel was running low. Patton and Montgomery bickered over who should get the last fuel reserves and push ahead. Eisenhower sided with the difficult British general, who planned to force his way across the Rhine into Holland, allowing the Allies to exploit the great harbor of Antwerp, which the British had seized virtually intact. Montgomery swung from his usual too-cautious approach to overconfidence. Ignoring warnings of strong German armor nearby, he ordered a parachute brigade dropped behind enemy

lines—and on the other side of town from the Arnhem bridge the paratroopers were to seize. The Germans cut them off, drove them away from the bridge, and shot them to pieces. Only a fifth of them survived to become prisoners or escape back across the Rhine.

Surprised by the stiffening German resistance, stunned by Montgomery's defeat, and above all, desperately low on fuel, the Allied advance slowed as autumn progressed. Eisenhower had hoped for an end to war in Europe by autumn; an obstinate Reich had held out. The Allies would have to wait until spring—winter was coming, and conditions would be too poor for any major offensive on the Western front. Eisenhower's only solace was that, given the weather and the continuous beating Germany was taking in the East, at least Hitler couldn't launch any counterattacks either.

## THE ARDENNES OFFENSIVE



Allied medium bombers over "The Bulge."

Hitler counterattacked on December 16, 1944, stunning the Allies by sending forth troops and armor under cover of fog and cold. Now, with the Eastern front in collapse and his final attempts at terror bombing London out of the war proven futile, he decided on a final, furious offensive that might change the course of the war.

While on the Eastern front the amount of territory between Germany and the Soviets was ample, in the West the front was uncomfortably close to the Reich's industrial base. While there might be time to stall and regroup against the Soviets, there was little time to waste before the Allies would be in the vital Ruhr region. Thus, as entire armies were being annihilated on the Polish frontier, Hitler massed more than twenty divisions of new troops and equipment in the West, augmenting it with the last reserves of manpower he could find within the Reich. Total mobilization had finally been declared by Speer. Now 16-year-old boys sat in the cockpits of the Luftwaffe's fighters and filled the ranks of German rifle companies.

Hitler planned to deliver a stunning, crushing blow, pushing the Allies across the Channel in a second Dunkirk. This new Blitzkrieg would undoubtedly be so successful that it would end in time to switch the forces back to the East before the Soviet winter offensive would begin. Hitler's estimation of the Allies, especially the Americans who now made up the bulk of the force in the West, was that they were a weak-willed assembly, ready to crack with the first serious defeat. For the third time in less than fifty years, Germany planned a sudden attack through the Low Countries.

Allied intelligence summed up the Wehrmacht as a spent force, unable to muster anything beyond a tenacious but doomed defense. Over the skies of Germany, Allied bombers flew virtually unopposed, pulverizing cities with impunity. The vast resources of Ukraine and Romania were in Soviet hands; only the oil fields of Hungary remained for Hitler to draw upon. The Allied lines were drawn thin across the Ardennes forest, but could hold firm until supplies arrived and a spring offensive could begin.

It was with this mutual underestimation that the last Nazi offensive began. In cold and snow, through the heavy woods of Luxembourg and Belgium, a 400,000 man German force slammed into a front guarded by 80,000 Americans who were outnumbered in tanks and (by a more than four-to-one ratio) artillery. In the long-gone days of 1940, the attack would have waited for a clear day, so that the mighty Luftwaffe could first bludgeon the enemy from the air. In 1944, the Germans instead counted on poor weather to keep the Allied air forces' far superior strength on the ground.



American ground crewmen prepare a holiday gift for the enemy.

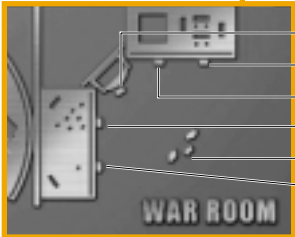
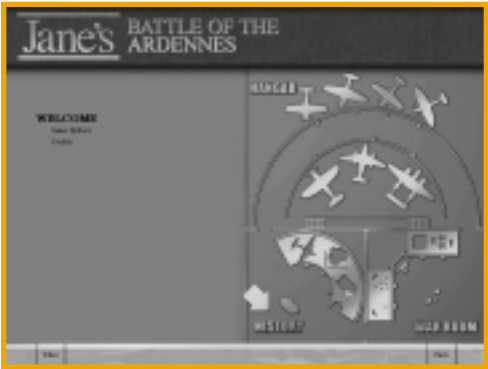
The Americans were caught totally off-guard. Eisenhower scrambled to move forces to the Ardennes as two divisions were destroyed and others were pushed back toward the strategic town of Bastogne. A division of US paratroopers secured the town just in time; the Germans surrounded it but failed to take it. This slowed the advance toward the Meuse River, giving American armor time to regroup and stop the attack on the water's east side.

To the south sat the American 3rd Army. Patton had been waiting for the fuel to take his attack east into Germany. When the sudden offensive began, Allied command was alarmed at the sparse defenses in the German path, and the time it would take distant reinforcements to arrive. To everyone's astonishment, Patton promised them he could disengage in the Saar, change direction, and swing north to relieve Bastogne in 48 hours. To everyone's further astonishment, he did just that, not only getting his forces to the front but hurling them into combat against the German armor besieging the city. He smashed his way through in the face of brutal panzer counterattacks, breaking the iron ring around Bastogne and freeing the pinned 101st Airborne Division.

Despite the help Montgomery's timidity gave them, the Germans' bout of good luck came to an end on Christmas Eve 1944, when the bad weather which kept the Allied air forces grounded gave way. In the cold, clear skies over the Ardennes, over 3,000 planes took to the air, and aimed for the slowly stalling German advance. To the east, the Luftwaffe had orders to attempt yet another air offensive against the enemy. Untrained pilots with little ammunition and less fuel climbed into what was left of the Luftwaffe with visions of chasing the Allied planes (by now outnumbering them ten-to-one) from the sky.

So the Allies and Nazi Germany found themselves, on the Western Front, in desperate battle. Hitler was flinging his last reserves in a final assault, convinced he could sweep his enemies into the Atlantic and buy time to win in the East. Both sides prepared to throw all they had into this showdown for control of the war's direction, and perhaps its outcome. At the end of 1944, the future of the planet was being decided on the ground and in the skies above the dense forests of the Ardennes. The West had to get reinforcements to the lines before they were overwhelmed, and hope for the weather to clear so their superior air power could be deployed.

# MUSEUM MAP



# THE EXHIBITIONS

Upon entering the museum, you see the Welcome Kiosk. If you want to jump right into flight, click the **Fly Now!** poster hanging in the top center of the screen. You immediately begin a quick mission without configuring your flight.



JUMP DIRECTLY  
INTO A MISSION

## NAVIGATING THE MUSEUM

QUICK NAVIGATION  
BUTTON

BACK BUTTON

CLICK ON AN ACTIVE  
LABEL TO MOVE  
FORWARD



To go to the previous screen, left-click the BACK button in the top left corner of the screen.

Use the QUICK NAVIGATION button to jump to another part of the museum. Click to bring up a screen listing the various locations in the museum. Select a location to be instantly transported there.

**PANNING YOUR VIEW**

At some locations, you may need to pan your view in order to see everything before you. To pan your view, move the mouse cursor to the left or right side of the screen.

**VIEWING KIOSKS**

Each museum room has a number of kiosks. When you move the mouse over a kiosk, it lights up. Click on a kiosk to view the content at that station.



The content you see on a kiosk monitor varies. Some kiosks display information on vehicles or historical subjects. Others select a mission.

**INFORMATION KIOSKS**

All Information Kiosks have a contents page. Here you choose the subject about which you want to learn.



When you move your mouse over the contents page, the option under the mouse turns white. Click to view detailed information on the subject. Select the **BACK** button to exit the kiosk screen.

**Video Button:** Many kiosks have an additional Video button. Use this to watch video reference material on the current subject.

## Viewing Information



DISPLAY THE PREVIOUS  
SUBJECT IN THE CONTENTS

DISPLAY THE NEXT  
SUBJECT IN THE CONTENTS

RETURN TO THE  
CONTENTS PAGE

GO TO THE  
PREVIOUS  
PAGE OF  
INFORMATION

GO TO THE  
NEXT PAGE OF  
INFORMATION

## Mission Kiosks

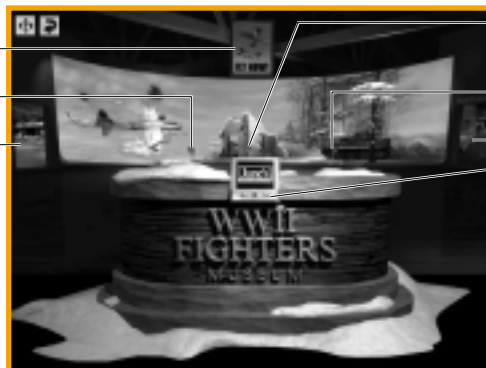
The Mission Kiosks are found only in the War Room. The controls in the mission kiosks vary depending on the type of mission. See the *Gameplay Guide* included in your *Jane's® WW II Fighters* box for information on selecting missions and building your own missions.

## WELCOME DESK

JUMP DIRECTLY  
INTO A MISSION

GO TO AIR FORCES  
KIOSK

GO TO HANGAR



GO TO HISTORICAL  
BACKGROUND  
KIOSK

GO TO GROUND  
FORCES KIOSK

GO TO WAR ROOM  
SET GAME OPTIONS,  
VIEW CREDITS, OR  
WATCH THE GAME  
INTRO ANIMATION

**INFO ROOM**

In the Info Room, you can learn about bombers and other aircraft that operated over Europe, as well as the types of ground vehicles and weapons that operated on the Western Front in late 1944. Also, the Historical Background Kiosk provides you with information on the Ardennes Offensive, known in the US as the Battle of the Bulge.



GO TO HANGAR

VIEW INFORMATION  
ON ALLIED AND  
AXIS BOMBERS  
AND TRANSPORTS

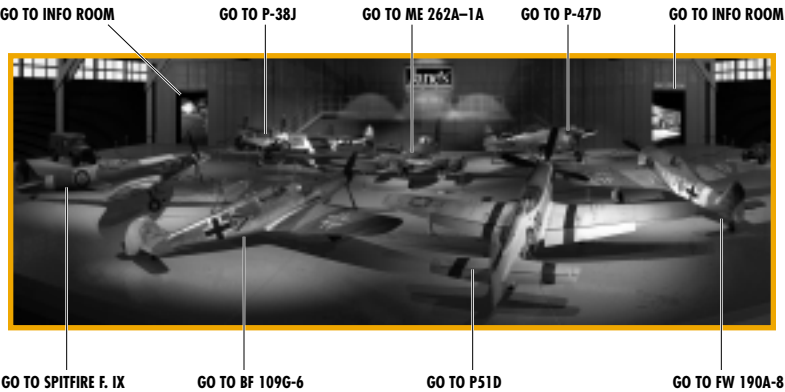
VIEW HISTORICAL  
BACKGROUND ON  
THE ARDENNES  
OFFENSIVE

VIEW INFORMATION  
ON ALLIED AND AXIS  
GROUND VEHICLES

GO TO WAR ROOM

**HANGAR**

In the Hangar, you can learn about the museum’s featured aircraft.



GO TO INFO ROOM

GO TO P-38J

GO TO ME 262A-1A

GO TO P-47D

GO TO INFO ROOM

GO TO SPITFIRE F. IX

GO TO BF 109G-6

GO TO P51D

GO TO FW 190A-8

**VIEWING THE AIRCRAFT**

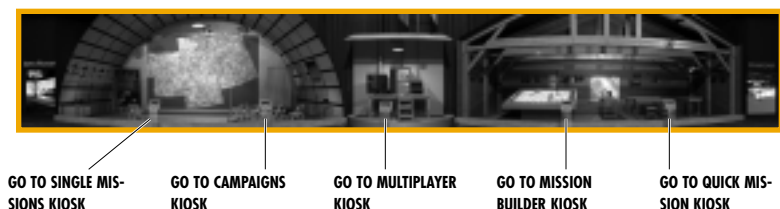
When viewing an airplane, you can go take a closer look at the cockpit, armament, and powerplant. The curator provides commentary on each aspect of the airplane.



**Special Test Flight Buttons:** Each of the Airplane Kiosks in the Hangar has a Test Flight button. Click this to fly the airplane of your choice in a non-hostile environment. Here you can test your flying and gunnery skills.

## WAR ROOM

In the War Room, you can select a single mission, build a custom mission of your own, start or continue a campaign, or join a multiplayer game. In addition, a special Aces Kiosk has video interviews with the aces who flew the actual planes.



## SELECTING MISSIONS

The controls in the mission kiosks vary depending on the type of mission. See the *Gameplay Guide* included in your *Jane's WW II Fighters* box for information on selecting missions and building your own missions.

# JANE'S® WW II FIGHTERS

## *Museum Collection*

In the 1930s, the antiquated, wooden biplanes of WW I were replaced by a new generation of sleek, metallic monoplanes that would redefine combat. Improvements in the engines, airframes, and firepower of these new aircraft fostered the great race of the decade—which country could create the fastest, most destructive flying machine in the world.

### FOCKE-WULF FW 190A-8

Germany prepared for war with the expectation that mobile warfare and combined arms would make any future conflict a brief if violent affair. It was widely believed that a successor to the Luftwaffe's frontline fighter, the Messerschmitt Bf 109, would hardly be necessary in the age of Blitzkrieg warfare. Thus it was with unusual foresight that the *Reichsluftfahrtministerium* (RLM), or Air Transport Ministry, chose to fund the development of an air superiority fighter in 1938, just as the Luftwaffe was standardizing on Messerschmitt's outstanding fighter. Who would have guessed then that a particularly compact airplane—designed by Kurt Tank and his team at Focke-Wulf—would become one of the most successful propeller-driven fighters ever produced in great numbers?

Certainly the officials at the RLM did not expect much from Tank's machine. True, the airplane was small and sleek, with an attractively thin fuselage, extremely low-drag profile, and excellent structure. But the fact that it was built around a bulky radial engine instead of a narrow inline engine did not bode well for its future. Three prototypes powered by 18-cylinder BMW 139 radial engines were ordered and built, the first flight occurring in early June 1939. The engines were found to be wanting and were replaced by the heavier but more powerful 1,192 kW (1,600 hp) BMW 801C. The added weight forced some changes in the airframe, including moving the cockpit further aft in order to shift the center of gravity; combined with a now larger engine cowling, the pilot's view was diminished slightly. The wing was also lengthened, though this was more beneficial than detrimental.

Trials with pre-production aircraft revealed teething trouble with the airplane's ten-blade cooling fan, but the overall impression of the fighter was that it was a delight to fly. Orders were delivered for a hundred Fw 190A-1 aircraft armed with four 7.7 mm MG 17 machine guns—two in the cowling and another pair in the wing roots—all firing through the propeller. To increase firepower, 20 mm MG FF cannons were added to points outboard of the landing gear. By the time the A-2 arrived, the wing root guns were being replaced by the new 20 mm MG 151/20, necessitating the bulged plates on the upper wing surfaces.

It was the Fw 190A-3 powered by the 1,268 kW (1,700 hp) BMW 801D-2 that became a menace to the RAF in the summer of 1942. Flying against Spitfire Vs, the Fw 190s proved themselves in every category of performance save turning ability. Able to initiate or break off combat at will, the Fw 190s dominated the skies over northwest Europe. The power of the new fighter was such that the English would have to scramble to wrest air superiority from a smaller Luftwaffe force facing them across the channel.

A number of Fw 190A sub-variants followed to fulfill an ever-widening number of roles. Originally intended to be an air superiority fighter, the *Würger* (“butcher bird”) quickly became a jack-of-all-trades, armed with cameras for reconnaissance; external fuel tanks for long-range missions; bombs for use as a fighter-bomber; tropical equipment for desert-fighting; wing pods for use as a bomber-destroyer; additional armor for bomber-ramming; radar equipment for use as a night-fighter; bomb racks for carrying torpedoes; and various combinations of the above.

As the war progressed, the Fw 190 assumed roles earlier held by such esteemed German aircraft as the Ju 87 *Stuka* and other close support aircraft. Beginning in late 1942, the heavily-armored Fw 190F—which also featured an incredible number of sub-variants—was developed for use in the ground attack role. This was followed by the 190G series, a close support version with additional fuel for increased combat range.

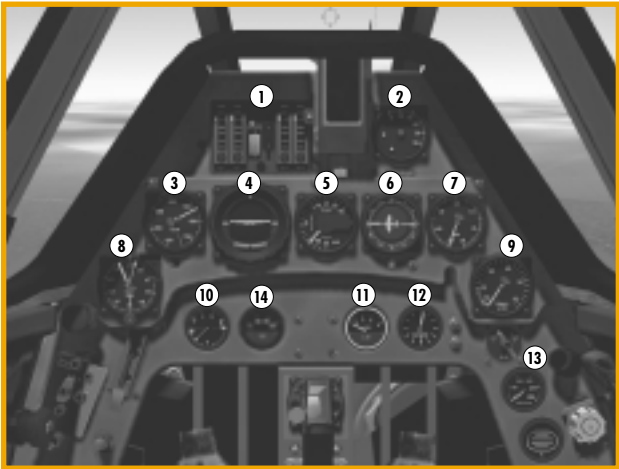
As the radial engine Fw 190 was being perfected, Focke-Wulf simultaneously developed versions of the fighter (190B and C series) with inverted-V liquid-cooled inline engines. The radial engine 190s performed poorly at high-altitude, and as defense of the Reich took on importance, the need for a heavily-armed high-altitude fighter became greater. The result was the famous 190D or “Dora” series of fighters, which began to see service only in late 1944. Powered by a 1,323 kW (1,776 hp) Junkers Jumo 213A-1 engine, the Fw 190D was considered on a competitive footing with the P-51 or Spitfire IX.

In total, just over 20,000 Fw 190s of all types would be produced by war’s end.

## FW 190A-8 DATA

<b>Engines</b>	One 1,268 kw (1,700 hp) BMW 801D-2
<b>Wing Span</b>	10.5 m (34 ft 5.5 in)
<b>Length</b>	8.96 m (29 ft 4.75 in)
<b>Max T-O Weight</b>	4,900 kg (10,802 lb)
<b>Max Level Speed</b>	657 km/h (408 mph)
<b>Range</b>	800 km (497 mi)
<b>Armament</b>	Two 12.7 mm machine guns, two 20 mm cannon, and either two-four 20 mm or two 30 mm cannon

FW 190A-8 COCKPIT



1. AMMUNITION COUNTER

2. RADIO DIRECTION FINDER

3. AIRSPEED INDICATOR

4. ARTIFICIAL HORIZON

5. RATE OF CLIMB INDICATOR

6. COMPASS

7. BOOST
8. ALTIMETER

9. TACHOMETER

10. FUEL AND LUBRICANT PRESSURE GAUGE

11. FUEL GAUGE

12. CLOCK

13. OXYGEN PRESSURE INDICATOR

14. ENGINE TEMPERATURE

FW 190A-8 GAME LOADOUTS

		Clean	Fuel	Gun Pods	Fuel, Gun Pods	500 kg	250 kg
Primary Guns	Type/Number	20 mm x 4	20 mm x 4	20 mm x 2	20 mm x 2	20 mm x 4	20 mm x 4
	Location	Wing/ Wingroot	Wing/ Wingroot	Wingroot	Wingroot	Wing/ Wingroot	Wing/ Wingroot
	Rounds/Gun	200	200	200	200	200	200
Secondary Guns	Type/Number	13 mm x 2	13 mm x 2	13 mm x 2	13 mm x 2	13 mm x 2	13 mm x 2
	Location	Cowling	Cowling	Cowling	Cowling	Cowling	Cowling
	Rounds/Gun	475	475	475	475	475	475
Secondary Guns	Type/Number	—	—	30 mm x 2	30 mm x 2	—	—
	Location	—	—	Wing Pods	Wing Pods	—	—
	Rounds/Gun	—	—	55	55	—	—
Bomb Load	Type	—	—	—	—	500 kg	250 kg
	Location	—	—	—	—	Centerline	Centerline
	Number	—	—	—	—	1	1
Drop Tank	Type	—	300 ltr	—	300 ltr	—	—
	Location	—	Centerline	—	Centerline	—	—
	Number	—	1	—	1	—	—

## LOCKHEED P-38 LIGHTNING

Developed before the war for use as a long-range, high-altitude fighter, the P-38 took on a wide variety of additional combat roles, including escort, fighter-bomber, photo-reconnaissance, torpedo-bomber, light transport, and even an airborne ambulance. The adaptable Lightning served until the end of the war—the only fighter to precede the war and remain in production until Japan surrendered. With its unusual twin-engine twin-boom design, it was certainly the most recognizable airplane in the entire Allied inventory—the Germans called it *der Gabelschwanz Teufel* or “the Fork-Tailed Devil”, while the Japanese term translated as “one pilot, two fighters.”

The P-38 was a credit to Lockheed, who in the early '30s had never developed a purely military airplane. It was designed to meet a 1936 US Army Air Corps specification for a pursuit fighter capable of 360 mph (576 km/h) at 20,000 ft (6,100 m). A proposal was accepted the following year, and the prototype XP-38 flew for the first time on 27 January 1939. In many respects it was a truly revolutionary airplane. At the time of its introduction, it was the fastest fighter in the world, and it also had the longest range. It had an all-metal flush-riveted skin and turbo-supercharger for solid high-altitude performance. And it was the first fighter to employ a tricycle landing gear.

The USAAC was pleased enough to issue a Limited Procurement order for 13 YP-38 fighters. These were fitted with two 1,150 hp (858 kW) Allison V-1710-27/29 engines and carried a powerful array of guns in the nose: one 37 mm cannon, two .30 caliber machine guns, and two .50 caliber machine guns.

An additional thirty production fighters designated P-38 were delivered in July 1941. The .30 caliber guns were replaced by additional .50 caliber guns, and pilot armor was added. These aircraft were turned over to training duties when the first combat-ready version, the P-38D, arrived in August 1941. This version featured self-sealing fuel tanks as well as a redistribution of the elevator balance weights, which improved dive recovery and eliminated problems associated with tail-buffeting.

The P-38E introduced what would become the fighter's standard gun armament: four .50 caliber machine guns in the nose forming an arc over one 20 mm cannon. This was followed by the P-38F, which was fitted with two 1,325 hp (988 kW) V-1710-49/53 engines and underwing racks for up to two 1,000 lb bombs or long-range drop tanks. The latter increased the airplane's combat range to an astonishing 1,750 miles (2,816 km).

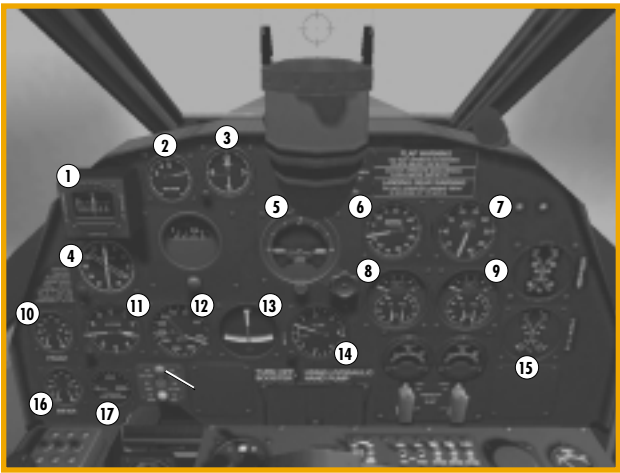
The P-38G and H each saw increases in engine performance. The P-38J, which entered service in August 1943, was powered by two 1,425 hp (1,063 kW) V-1710-89/91 engines and introduced powered ailerons and a better cooling system. This was followed by the P-38L, the most numerous version built and the first to carry underwing rockets. Some P-38Js and Ls

were later adapted as pathfinders, complete with a bombardier and Norden bombsight in a transparent nose. The P-38M, which arrived too late to serve in the European theater, was a two-seat night-fighter carrying a radar in a chin pod.

**P-38J DATA**

<b>Engines</b>	Two 1,425 hp (1,062 kW) Allison V-1710-89/91
<b>Wing Span</b>	52 ft 0 in (15.85 m)
<b>Length</b>	37 ft 10 in (11.53 m)
<b>Max T-O Weight</b>	21,600 lb (9,798 kg)
<b>Max Level Speed</b>	414 mph (666 km/h)
<b>Range</b>	450 mi (724 km)
<b>Armament</b>	One 20 mm cannon and four .50 caliber machine guns, plus up to 2,000 lb of external stores

**P-38J COCKPIT**



1. COMPASS

2. SUCTION GAUGE

3. CLOCK

4. DIRECTIONAL GYRO

5. ARTIFICIAL HORIZON

6. MANIFOLD PRESSURE GAUGE

7. TACHOMETER
8. ENGINE GAUGE CLUSTER:  
FUEL & OIL PRESSURE,  
TEMPERATURE (LEFT ENGINE)

9. ENGINE GAUGE CLUSTER:  
FUEL & OIL PRESSURE,  
TEMPERATURE (RIGHT ENGINE)

10. FRONT (RESERVE) FUEL TANKS  
GAUGE

11. ALTIMETER
12. AIRSPEED INDICATOR

13. BANK AND TURN INDICATOR

14. RATE OF CLIMB INDICATOR

15. CARBURETOR AIR TEMPERATURE  
GAUGE

16. REAR (MAIN) FUEL TANKS GAUGE

17. HYDRAULIC PRESSURE GAUGE

## P-38J GAME LOADOUTS

		Clean	Fuel	HVAR	Fuel, HVAR	500 lb	HVAR 500 lb	1000 lb
Primary Guns	Type/Number	.50 cal x 4	.50 cal x 4	.50 cal x 4	.50 cal x 4	.50 cal x 4	.50 cal x 4	.50 cal x 4
	Location	Fuselage	Fuselage	Fuselage	Fuselage	Fuselage	Fuselage	Fuselage
	Rounds/Gun	500	500	500	500	500	500	500
Secondary Guns	Type/Number	20 mm x 1	20 mm x 1	20 mm x 1	20 mm x 1	20 mm x 1	20 mm x 1	20 mm x 1
	Location	Fuselage	Fuselage	Fuselage	Fuselage	Fuselage	Fuselage	Fuselage
	Rounds/Gun	150	150	150	150	150	150	150
Bombs	Type	—	—	—	—	500 lb	500 lb	1,000 lb
	Location	—	—	—	—	Wing	Wing	Wing
	Number	—	—	—	—	2	2	2
Rockets	Type	—	—	HVAR	HVAR	—	HVAR	—
	Location	—	—	Wing Racks	Wing Racks	—	Wing Racks	—
	Number/Rack	—	—	5	5	—	5	—
Drop Tanks	Type	—	165 US gal	—	165 US gal	—	—	—
	Location	—	Wing	—	Wing	—	—	—
	Number	—	2	—	2	—	—	—

## MESSERSCHMITT BF 109

Perhaps the most famous German fighter ever built, the Bf 109 earned a place in the annals of all-time great warplanes by virtue of its early-war performance alone—to say nothing of the fact that it faithfully served as the mainstay of the Luftwaffe from before hostilities commenced in 1939 until the capitulation of Germany in May 1945. A fundamentally good design allowed it to be employed in an incredibly wide variety of tasks, and the fact that some 35,000 were built speaks volumes of the airplane's usefulness.

In 1933 the *Reichsluftfahrtministerium* (Air Transport Ministry), or RLM, issued a specification for a monoplane fighter to replace the biplane fighters (Arado Ar 68 and Heinkel He 51) then available to the still-clandestine Luftwaffe. Contracts for prototypes were awarded to Arado, Bayerische Flugzeugwerke, Focke-Wulf, and Heinkel. Few expected Willy Messerschmitt and Bayerische Flugzeugwerke to produce a winning design in the area of high speed fighters, whatever the success of their earlier Bf 108 Taifun touring airplane. When it came time for competitive trials, however, Messerschmitt's Bf 109 V1 performed admirably against the Ar 80 V1, Fw 159 V1, and He 112 V1. A low wing monoplane with retractable landing gear, the 109 was clearly a breed apart from the open cockpit designs proposed by Arado and Focke-Wulf, or Heinkel's high-wing fighter. The RLM ordered an additional 10 experimental Bf 109s, but—hedging their bets perhaps—ordered 10 of the Heinkel design as well. This led to further trials in late 1935, during which the Bf 109 proved its superiority.

Ironically, the 109 first flew under the power of imported Rolls-Royce Kestrel VI engine, since the Jumo 210 engine intended for it was not finished.

The proposed Bf 109A was cancelled when its armament of just two 7.9 mm MG 17 machine guns in the upper cowling was deemed inadequate. Provision was made for a possible third gun firing through the airscrew, and a number of Bf 109B-1, B-2, and C fighters were delivered to Luftwaffe units operating with the Condor Legion in Spain. Pilots gained considerable experience while participating in the Spanish Civil War, formulating tactics and suggesting improvements to the 109, which already was proving capable of going head-to-head with the best Republican fighter, the Russian-built Polikarpov I-16.

The Bf 109D powered by the Daimler-Benz DB 600 engine was produced in limited quantities, but by the time the war broke out in 1939, the Bf 109E with the more powerful 820 kW (1,100 hp) DB 601A engine was taking the place of the 'Dora' on the production lines. The 109E or 'Emil' housed additional MG 17 machine guns or 20 mm MG FF cannon in the wings, and some variants housed a fifth MG FF cannon in the propeller hub. The Emil was produced in great numbers—it was the primary fighter used in the Battle of France and the Battle of Britain—and many were exported to foreign clients in return for hard cash. The airplane's tremendous speed advantage was its greatest asset in the first few years of the war. It suffered against early RAF Spitfires in the area of turning performance, and its fuel capacity was small (a serious liability, as the Germans discovered, during the Battle of Britain), but otherwise the Bf 109E was the superior machine. The 'Emil' began to take on additional roles: fighter-bomber, reconnaissance airplane, high-altitude interceptor with power-boosting, and a modified version for fighting in the Mediterranean.

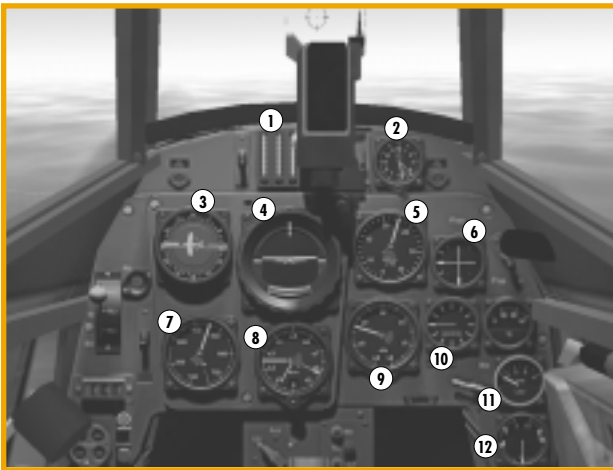
By the time Germany invaded the Soviet Union in 1941, the Bf 109F was being introduced. This airplane—now powered by an 894.2 kW (1,200 hp) DB 601N or 969 kW (1,300 hp) DB 601E engine—eliminated the aerodynamically unattractive braces under the tailplane while introducing a retractable tailwheel. The wing guns were eliminated entirely—pilots would now rely on a pair of MG 17s in the upper nose deck, and a single high-velocity MG 151/20 cannon firing through the airscrew.

In the summer of 1942, the Luftwaffe introduced the Bf 109G into service. This model was powered by the 1,100 kW (1,475 hp) DB 605 series of engines, the intention being to increase the airplane's speed performance at the expense of maneuverability. The 'Gustav' was built in larger numbers than any other variant of the 109—despite the fact that it was no longer the equal of the newest Allied fighters—and G models would continue to roll off the production line until the end of the war. A few other versions were also developed, including the high-altitude Bf 109H (with increased wing span) and the Bf 109K, which was basically an improved 109G.

## BF 109G-6 DATA

<b>Engines</b>	One 1,099-1,490.4 kW (1,475-2,000 hp) Daimler-Benz DB 605
<b>Wing Span</b>	9.92 m (32 ft 6.5 in)
<b>Length</b>	8.84 m (29 ft .5 in)
<b>Max T-O Weight</b>	3,150-3,678 kg (6,945-8,109 lb)
<b>Max Level Speed</b>	621 km/h (386 mph)
<b>Range</b>	563 km (350 mi)
<b>Armament</b>	One 30 mm MK 108 cannon, two 12.7 mm MG 131 machine guns, and (optional) two 20 mm MG 151 cannon. One 250 kg bomb or 500 kg bomb with release take-off carriage.

## BF 109G-6 COCKPIT



- |   |                               |
|---|-------------------------------|
| 1. AMMUNITION COUNTERS                            | 7. ALTIMETER                  |
| 2. CLOCK  | 8. AIRSPEED INDICATOR         |
| 3. COMPASS  | 9. TACHOMETER                 |
| 4. TURN AND BANK INDICATOR/<br>ARTIFICIAL HORIZON | 10. PROPELLER PITCH INDICATOR |
| 5. MANIFOLD PRESSURE GAUGE                        | 11. FUEL GAUGE                |
| 6. RADIO DIRECTION FINDER                         | 12. OIL AND PRESSURE GAUGE    |

BF 109 GAME LOADOUTS

		Clean	Fuel	Gun Pods	Fuel, Gun Pods	500 kg	250 kg
Primary Gun	Type/Number	30 mm x 1	30 mm x 1	30 mm x 1	30 mm x 1	30 mm x 1	30 mm x 1
	Location	Aircrew	Aircrew	Aircrew	Aircrew	Aircrew	Aircrew
	Rounds/Gun	60	60	60	60	60	60
Secondary Guns	Type/Number	13 mm x 2	13 mm x 2	13 mm x 2	13 mm x 2	13 mm x 2	13 mm x 2
	Location	Cowling	Cowling	Cowling	Cowling	Cowling	Cowling
	Rounds/Gun	300	300	300	300	300	300
Secondary Guns	Type/Number	—	—	20 mm x 2	20 mm x 2	—	—
	Location	—	—	Wing Pods	Wing Pods	—	—
	Rounds/Gun	—	—	120	120	—	—
Bomb Load	Type	—	—	—	—	500 kg	250 kg
	Location	—	—	—	—	Centerline	Centerline
	Number	—	—	—	—	1	1
Drop Tank	Type	—	300 ltr	—	300 ltr	—	—
	Location	—	Centerline	—	Centerline	—	—
	Number	—	1	—	1	—	—

MESSERSCHMITT ME 262

In early 1939, the *Reichsluftfahrtministerium* (Air Transport Ministry), or RLM, requested that Messerschmitt AG design a fighter powered by a pair of the new reaction-turbine engines then under development. Surely no one imagined that a war launched in that same year would see the development, production, and combat deployment of an airplane propelled by such revolutionary—and still experimental—means. However, it is difficult to understand why, once the war got underway, German procurement officers did not give top priority to the development of Messerschmitt’s P 1065 V1 project, or for that matter the equally promising turbojet-powered Heinkel He 280 V2 prototype. Germany’s overwhelming successes in the first few years of the war certainly contributed to a general feeling of complacency concerning the next generation of fighters, and at any rate, German manufacturers had their hands full just trying improve the aircraft already streaming out of the factories. Nonetheless, it’s fascinating to speculate what the outcome of the European war would have been had German jet-powered fighters been available as early as 1943, when American strategic bombing forces were beginning to tie up large numbers of Luftwaffe resources.

Whatever one’s opinion, Messerschmitt’s project was not a priority when the P 1065 V1 was fitted with a Junkers Jumo 210G propeller engine in the spring of 1941 in order to test the airplane in powered flight. The Me 262 V1, as it was now known, showed promise in this and subsequent flights. By December 1941, experimental BMW 003 engines arrived and were installed on the airplane. These proved unreliable when both engines

experienced a flame-out shortly after takeoff on their maiden flight. Fortunately, an alternate power plant was to be found in the equally experimental 5.88 kN (1,323 pounds static thrust) Junkers Jumo 004. The Junkers engines were fitted to the Me 262 V3, and these took the airplane on its first successful jet-powered flight on 18 July 1942.

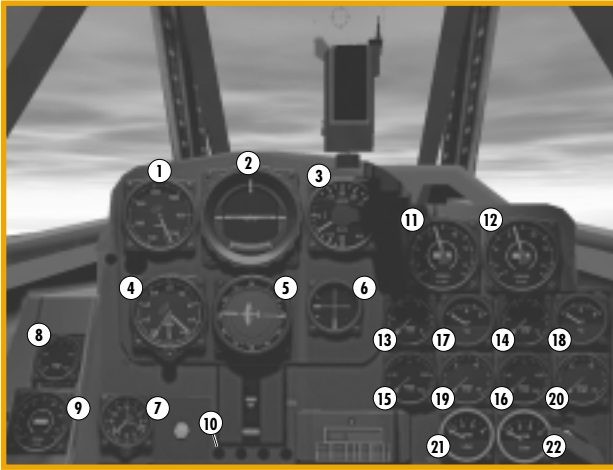
Contracts for further prototypes were awarded, and the jet earned critical support when Adolf Galland, in his position as *General der Jagdflieger* (General of Fighter Pilots), recommended that the airplane be developed at the expense of less-promising projects. The Luftwaffe ordered 100 production aircraft, but a particularly destructive raid by the US Eighth Air Force forced Messerschmitt to relocate its jet center south to Oberammergau in Bavaria. This caused an unfortunate delay in production, which was exasperated by a shortage of skilled personnel needed to produce the sophisticated airplanes. It wasn't until October 1943 that the Me 262 V6 prototype—with retractable tricycle landing gear, trailing-edge flaps, leading-edge slats, and provision for four 30 mm MK 108 cannon—was tested and approved.

Pre-production Me 262A-0s were delivered to operational fighter-bomber units in December 1943. These were tested in France in the early summer of 1944. The first production version, the Me 262A-1a, arrived shortly thereafter. Configured as a fighter/interceptor, it was powered by two 8.825 kN (1,984 static thrust) Junkers Jumo 109-004B-1 eight-stage axial-flow turbojets and was armed with four 30 mm MK 108 cannons. A fighter-bomber version—the Me 262A-2a—was armed with two 30 mm cannons and could carry two 250 kg bombs. Other versions included a reconnaissance airplane, a night fighter, and a number of trial models.

## ME 262A-1a DATA

<b>Engines</b>	Two 8.825 kN (1,984 lb st) Junkers Jumo 109-004B-1 or 004B-4 turbojets
<b>Wing Span</b>	12.5 m (41 ft 1/8 in)
<b>Length</b>	10.61 m (34 ft 9.75 in)
<b>Max T-O Weight</b>	7,045 kg (15,531 lb)
<b>Max Level Speed</b>	868 km/h (539 mph)
<b>Range</b>	1,050 km (652 mi)
<b>Armament</b>	Four 30 mm cannon

## **ME 262A-1a COCKPIT**



1. AIRSPEED INDICATOR
2. TURN AND BANK INDICATOR/  
ARTIFICIAL HORIZON
3. RATE OF CLIMB INDICATOR
4. ALTIMETER
5. COMPASS
6. RADIO DIRECTION FINDER
7. CLOCK
8. OXYGEN PRESSURE GAUGE
9. OXYGEN FLOW INDICATOR
10. AMMUNITION COUNTER
11. TACHOMETER (LEFT ENGINE)
12. TACHOMETER (RIGHT ENGINE)

13. GAS PRESSURE INDICATOR (LEFT ENGINE)
14. GAS PRESSURE INDICATOR (RIGHT ENGINE)
15. INJECTION PRESSURE INDICATOR  
(LEFT ENGINE)
16. INJECTION PRESSURE INDICATOR  
(RIGHT ENGINE)
17. GAS TEMPERATURE INDICATOR  
(LEFT ENGINE)
18. GAS TEMPERATURE INDICATOR  
(RIGHT ENGINE)
19. OIL PRESSURE INDICATOR (LEFT ENGINE)
20. OIL PRESSURE INDICATOR (RIGHT ENGINE)
21. FUEL SUPPLY (LEFT ENGINE)
22. FUEL SUPPLY (RIGHT ENGINE)

**ME 262A-1a GAME LOADOUTS**

		Clean	R4M	250 kg
Main Guns	Type/Number	30 mm x 2	30 mm x 2	30 mm x 2
	Location	Fuselage (top ports)	Fuselage (top ports)	Fuselage (top ports)
	Rounds/Gun	100	100	100
2nd Guns	Type/Number	30 mm x 2	—	—
	Location	Fuselage	—	—
	Rounds/Gun	80	—	—
3rd Guns	Type/Number	—	—	—
	Location	—	—	—
	Rounds/Gun	—	—	—
Bomb 1	Type	—	—	250 kg
	Location	—	—	Centerline
	Number	—	—	2
Bomb 2	Type	—	—	—
	Location	—	—	—
	Number	—	—	—
Rockets	Type	—	R4M	—
	Location	—	Wing Racks	—
	Number/Rack	—	12	—
Drop Tanks	Type	—	—	—
	Location	—	—	—
	Number	—	—	—

**NORTH AMERICAN P-51 MUSTANG**

Measured by the standards of pure performance and its influence upon the course of the war, the P-51 was the best US fighter of the war and arguably the finest produced by any nation. Incredibly, the airplane that would become the renowned Mustang was designed and developed in a three-month crash program by a young company with no experience making fighter airplanes, North American Aviation. This was in the summer of 1940, and North American designers Raymond Rice and Edgar Schmued could take full advantage of technological advances not available to European and Japanese airplane manufacturers just a half a decade earlier. The most important advances incorporated by Rice and Schmued was a laminar-flow wing section—in which the thickest part of the wing is pushed further back, the effect being an overall lower drag quotient—and the positioning of the radiator duct. Referencing promising work done on prototypes of the P-40, the designers positioned the coolant system and radiator duct aft of the pilot and wing, which reduced drag and under certain conditions created a slight amount of positive thrust. This resulted in an extremely efficient airplane that could reach high speeds even while carrying an enormous amount of fuel—a long-range fighter of superlative performance had been born.

The prototype NA-73X flew on 26 October, 1940. A year later, the RAF began to receive the first of 320 Mustang I fighters. Evaluations proved the fighter was outstanding in all respects except high-altitude performance. The fault lay in the chosen power plant, the 1,150 hp (857 kW) Allison V-1710-F3R engine. The Mustang I fighters were assigned to ground attack duties and armed with four .50 caliber guns (two below the engine cowling and one in each wing) and four .303 inch guns. Three hundred Mustang IA fighters followed with an armament of four 20 mm cannon and provision for bombs.

By 1942, the USAAF began to take note of the airplane's potential and ordered a number of the fighters as low-altitude fighters (P-51 and P-51A), ground attack aircraft (A-36A), and reconnaissance airplanes (F-6As). Meanwhile, both sides began testing Mustangs with Rolls-Royce Merlin engines driving four-bladed propellers. The results were impressive—a maximum speed of 440 mph (710 km/h) was possible. In 1943 North American began delivering the P-51B and C (Mustang III), most of which were powered by a Packard-built 1,520 hp (1,133 kW) V-1650-3 engine. Armament consisted of four .50 caliber machine guns installed in the wings, with hard points for bombs or drop tanks. Photo-reconnaissance versions (F-6B and F-6C) were also produced.

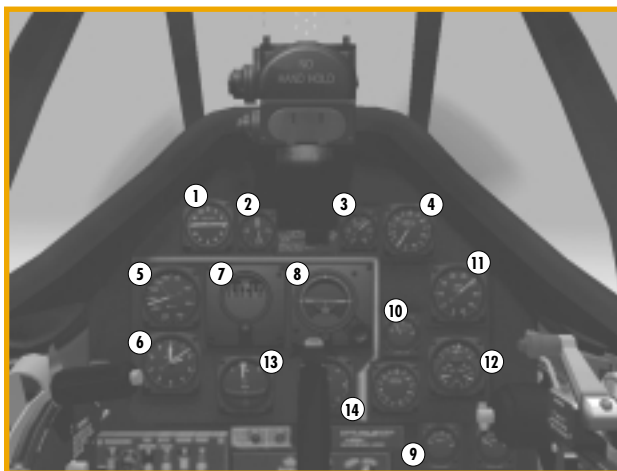
In 1944, the definitive P-51D (Mustang IV) version was introduced, and it was this fighter that would be produced in greater numbers than all other versions combined. It featured numerous improvements: a new 1,590 hp (1,186 kW) Packard V-1650-7 engine, an armament increase to six .50 caliber machine guns, and a teardrop-shaped clear 'bubble' canopy replacing the flush framed canopy. Later D models would also add an 85 US gallon (322 ltr) fuel cell behind the pilot's seat, and an extra rudder fin to relieve directional stability problems. A number of F-6D reconnaissance Mustangs were also produced.

By the close of the war, only minor improvements were possible. The P-51K and F-6K differed only in having an Aeroproducts propeller. North American also sought to improve performance by creating lightweight Mustangs, which resulted in the P-51H, L, and M.

### P-51D DATA

<b>Engines</b>	One 1,590 hp (1,186 kW) Packard V-1650-7
<b>Wing Span</b>	37 ft .5 in (11.29 m)
<b>Length</b>	32 ft 2.5 in (9.81 m)
<b>Max T-O Weight</b>	11,600 lb (5,206 kg)
<b>Max Level Speed</b>	437 mph (703 km/h)
<b>Range</b>	950-2,080 mi (1,529-3,347 km)
<b>Armament</b>	Six .50 caliber machine guns, plus up to 2,000 lb of external stores

## P-51D COCKPIT



- |                            |   |
|----------------------------|---|
| 1. RADIO DIRECTION FINDER  | 9. COOLANT TEMPERATURE GAUGE                                  |
| 2. CLOCK                   | 10. CARBURETOR AIR TEMPERATURE GAUGE                          |
| 3. SUCTION GAUGE           | 11. TACHOMETER  |
| 4. MANIFOLD PRESSURE GAUGE | 12. ENGINE GAUGE CLUSTER:<br>FUEL & OIL PRESSURE, TEMPERATURE |
| 5. AIRSPEED INDICATOR      | 13. TURN INDICATOR  |
| 6. ALTIMETER               | 14. VERTICAL SPEED INDICATOR                                  |
| 7. COMPASS                 |   |
| 8. ARTIFICIAL HORIZON      |   |

## P-51D GAME LOADOUTS

		Clean	Fuel	HVAR	500 lb	500 lb, HVAR
Primary Guns	Type/Number	.50 cal x 6	.50 cal x 6	.50 cal x 6	.50 cal x 6	.50 cal x 6
	Location	Wing	Wing	Wing	Wing	Wing
	Rounds/Gun	270*	270*	270*	270*	270*
Bombs	Type	—	—	—	500 lb	500 lb
	Location	—	—	—	Wing	Wing
	Number	—	—	—	2	2
Rockets	Type	—	—	HVAR	—	HVAR
	Location	—	—	Wing Racks	—	Wing Racks
	Number/Rack	—	—	3	—	3
Drop Tanks	Type	—	75 US gal	—	—	—
	Location	—	Wing	—	—	—
	Number	—	2	—	—	—

\* The two inner guns carry 500/gun

## REPUBLIC P-47 THUNDERBOLT

To anybody viewing Republic's P-47 during the war years, the airplane's most obvious characteristics were its monstrous size in comparison to other fighters and its resemblance to an oversized milk jug. But while the Thunderbolt was the largest and heaviest single-engine fighter of the war, it more than proved its effectiveness in virtually every theatre in which the US fought.

An experimental XP-47 project was begun in 1940, but events showed that greater performance, self-sealing fuel tanks, pilot armor, weapon pylons, and heavy armament were needed if the airplane was to compete in Europe. A totally new XP-47B was designed around a new power plant: the turbocharged Pratt & Whitney XR-2800 Double Wasp engine. The turbocharger was mounted in the underside of the rear fuselage. The engine exhaust passed under the wing to the turbocharger, where it was fed through a 'waste gate' valve system that controlled the amount of hot gas that, depending on altitude, drove a turbine. This powered a compressor that fed air via ducts and intercoolers to the engine, which increased power. The elaborate gas-exchange system took up a lot of space and gave the P-47 its particularly bottle-like appearance.

A massive 12 ft 2 in (3.7 m) tall propeller was required to utilize the power, which in turn required long landing gear. This left little room for the eight .50 caliber machine guns and their 425 rounds each of ammunition. Designer Alexander Kartveli solved the problem brilliantly by designing landing gear that shortened nine inches in length while retracting. The XP-47B flew on 6 May 1941, with the first production P-47Bs being delivered in June 1942 to the 56th Fighter Group at Mitchell Field in New York.

The B models had fabric covered ailerons and rudders which proved problematical. The P-47C replaced the faulty surfaces with ones covered in metal sheets, and incorporated other minor improvements. The P-47Cs were rushed off to England to fight in the European theater. At first the huge, ungainly birds were regarded with skepticism by the pilots, but opinions changed once its virtues were displayed: devastating firepower, an ability to turn altitude into speed (due to the aircraft's great weight), and unequaled toughness in the face of extreme battle damage.

The P-47D introduced a large number of improvements: new and more powerful versions of the R-2800 Double Wasp, increased internal fuel capacity, provision for jettisonable underwing drop tanks, the ability to carry weapon loads up to 2,500 lb (1,134 kg), and a new, wider Hamilton Standard Hydramatic propeller. With the D model, Thunderbolts carrying drop tanks could escort bombers deep into Germany.

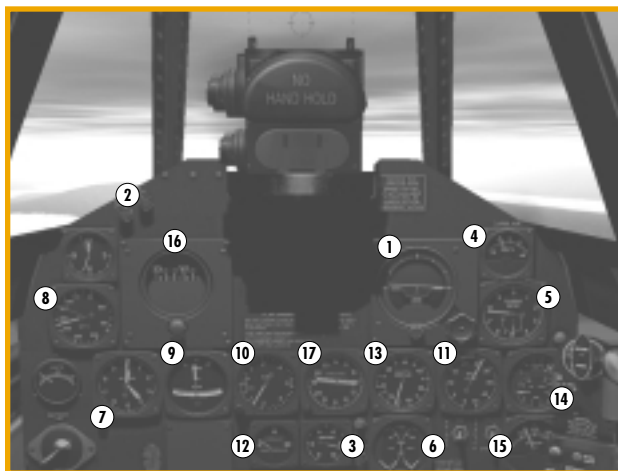
The other full-production versions were the P-47M and N. The M was a stripped-down version capable of 505 mph (811 km/h) and was intended

for use against Germany's flying bombs. The N model was a long-range variant for use in the Pacific. It had an increased wingspan and internal wing tanks that could carry 93 US gallons (352 ltr) of fuel in each wing.

## P-47D DATA

<b>Engines</b>	One 2,535 hp (1,889 kW) Pratt & Whitney R-2800-59 Double Wasp
<b>Wing Span</b>	40 ft 9.25 in (12.4 m)
<b>Length</b>	36 ft 1.25 in (11.03 m)
<b>Max T-O Weight</b>	19,400 lb (8,800 kg)
<b>Max Level Speed</b>	428 mph (690 km/h)
<b>Range</b>	590 mi (950 km)
<b>Armament</b>	Eight .50 caliber machine guns, plus up to 2,500 lb of external stores

## P-47D COCKPIT



- |   |  |
|---|--|
| 1. ARTIFICIAL HORIZON                       | 10. RATE OF CLIMB INDICATOR                                |
| 2. LANDING GEAR AND FLAP POSITION INDICATOR | 11. TACHOMETER   |
| 3. SUCTION GAUGE                            | 12. HYDRAULIC PRESSURE GAUGE                               |
| 4. CARBURETOR AIR TEMPERATURE GAUGE         | 13. MANIFOLD PRESSURE GAUGE                                |
| 5. TURBO TACHOMETER                         | 14. ENGINE GAUGE CLUSTER: FUEL & OIL PRESSURE, TEMPERATURE |
| 6. FUEL GAUGE                               | 15. CYLINDER HEAD TEMPERATURE GAUGE                        |
| 7. ALTIMETER                                | 16. COMPASS  |
| 8. AIRSPEED INDICATOR                       | 17. RADIO DIRECTION FINDER                                 |
| 9. BANK AND TURN INDICATOR                  |  |

P-47D GAME LOADOUTS

		Clean	Fuel	HVAR	Fuel, HVAR	500 lb	500 lb HVAR	1000 lb
Primary Guns	Type/Number	.50 cal x 8	.50 cal x 8	.50 cal x 8	.50 cal x 8	.50 cal x 8	.50 cal x 8	.50 cal x 8
	Location	Wing	Wing	Wing	Wing	Wing	Wing	Wing
	Rounds/Gun	425	425	425	425	425	425	425
Bombs	Type	—	—	—	—	500 lb	500 lb	1,000 lb
	Location	—	—	—	—	Wing	Wing	Wing
	Number	—	—	—	—	2	2	2
Rockets	Type	—	—	HVAR	HVAR	—	HVAR	—
	Location	—	—	Wing Racks	Wing Racks	—	Wing Racks	—
	Number/Rack	—	—	5	5	—	5	—
Drop Tanks	Type	—	75 US gal	—	75 US gal	—	—	—
	Location	—	Wing	—	Wing	—	—	—
	Number	—	2	—	2	—	—	—

SUPERMARINE SPITFIRE

Though its numerical contribution to the Battle of Britain was not as great as that of the Hurricane, the Spitfire’s psychological contribution was enormous. The airplane became a proud symbol of England’s resolute defiance of Hitler, defending the kingdom from the German bomber armadas and thereby denying Hitler the critical precondition he would need in order to launch an invasion of the British Isles. But the Spitfire was more than a potent symbol—the strength of its design was proven in six years of war, during which (through numerous modifications) it remained a frontline fighter that could challenge the best that Germany had to offer.

The Spitfire originated with a 1931 Air Ministry specification calling for a single seat fighter to replace the British Bulldog. Supermarine’s prototype was not accepted, but it prompted Supermarine’s brilliant designer, R.J. Mitchell, to begin private work on a new prototype. Known as the Type 300, Mitchell’s new airplane would incorporate the new 1,000 hp (745.7 kW) Rolls-Royce PV-12 engine, which only later would be known as the Merlin. The airplane clearly had great potential, and the Air Ministry subsequently funded a prototype, followed closely by an order for over 300 Spitfires in July 1936 (later increased by an additional 500).

The Spitfire Mk I was a conventional low-wing monoplane of all-metal stressed skin and fabric-covered control surfaces, powered by a 1,030 hp (767.5 kW) Rolls-Royce Merlin II or III engine. Armament consisted of either eight .303 inch machine guns or two 20 mm cannons and four .303 inch guns. Production of the Mk I proceeded until 1939, during which the aircraft underwent numerous modifications: the flat canopy panels were replaced by curved canopy; armor plating was added behind the pilot; and

electric power was added to the undercarriage controls. Additionally, the fixed-pitch two-bladed wooden propeller was replaced by a two-speed three-bladed propeller.

The Spitfire II was powered by the 1,175 hp (876.1 kW) Merlin XII and used 100 (rather than 87) octane fuel. Other additions were bulletproof windscreens, self-sealing fuel tanks, and a jettisonable 'slipper' drop tank fitted under the fuselage. Following the Battle of Britain, the RAF began phasing out the Hurricane while introducing the Spitfire V, initially fitted with a Merlin 45 engine. This airplane was the first Spitfire to be deployed in large numbers overseas, and thus the first to be fitted with tropical equipment. It would become the most numerous of all Spitfire models. Sub-variants were also developed to carry drop tanks or bombs.

By 1941, the Germans unleashed the Focke-Wulf 190 on the Channel Front, and it took a devastating toll on the Spitfire V. The Spitfire VII powered by the 1,565 hp (1,167 kW) Merlin 61 engine was already on the drawing boards, but before this version could be fully developed an interim solution to the Focke-Wulf threat would need to be found. This arrived in the form of the Spitfire IX, an excellent fighter considered by many to be the finest Spitfire of all. It was eventually produced as a standard fighter in great numbers (second only to the Mk V itself). There were three sub-variants: standard (F.IX), low-altitude (LF.IX), and high-altitude (HF.IX).

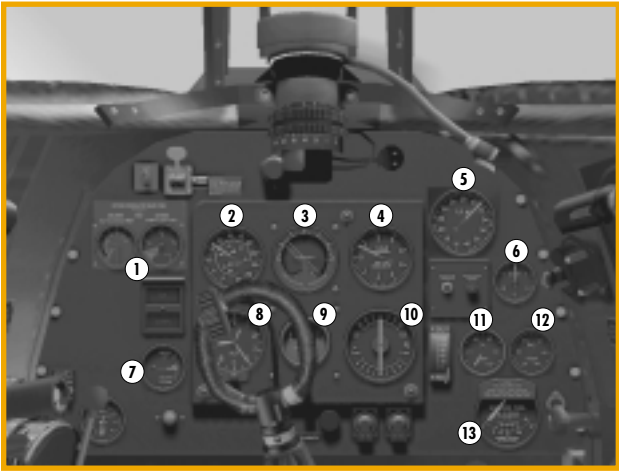
Two variants with Griffon engines, the Mk XII and Mk XIV, were also produced. Of these, the Mk XIV was the one used in quantity during and after the war. Featuring a Griffon 65 or 66 engine and a five-bladed propeller, it was intended for combat at all altitudes. The Spitfire XVI was powered by a Packard-built Merlin 266 engine. The final versions of the Spitfire were the Mk 21, 22, and 24, fitted with Merlin 61, Griffon 85 or other engines.

The total number of Spitfires built was well over 20,000.

## **SPITFIRE F. IX DATA**

<b>Engines</b>	One 1,290 hp (962 kW) Rolls-Royce Merlin 63
<b>Wing Span</b>	36 ft 10 in (11.2 m)
<b>Length</b>	31 ft 3.5 in (9.5 m)
<b>Max T-O Weight</b>	9,500 lb (4,309 kg)
<b>Max Level Speed</b>	408 mph (656 km/h)
<b>Range</b>	435 mi (700 km)
<b>Armament</b>	Two 20mm cannons and four .303 in. machine guns

SPITFIRE F. IX COCKPIT



1. OXYGEN REGULATOR

2. AIRSPEED INDICATOR

3. ARTIFICIAL HORIZON

4. RATE OF CLIMB INDICATOR

5. TACHOMETER

6. BOOST PRESSURE GAUGE

7. ELEVATOR TABS POSITION
8. ALTIMETER

9. COMPASS

10. TURN AND BANK INDICATOR

11. OIL TEMPERATURE GAUGE

12. RADIATOR TEMPERATURE GAUGE

13. FUEL GAUGE

SPITFIRE F. IX GAME LOADOUTS

		Clean	Fuel	250 lb	Fuel, 250 lb	250 lb, 500 lb
Primary Guns	Type/Number	.303 in x 4	.303 in x 4	.303 in x 4	.303 in x 4	.303 in x 4
	Location	Wing	Wing	Wing	Wing	Wing
	Rounds/Gun	350	350	350	350	350
Secondary Guns	Type/Number	20 mm x 2	20 mm x 2	20 mm x 2	20 mm x 2	20 mm x 2
	Location	Wing	Wing	Wing	Wing	Wing
	Rounds/Gun	120	120	120	120	120
Bomb Load	Type	—	—	250 lb	250 lb	250 lb
	Location	—	—	Wing	Wing	Wing
	Number	—	—	2	2	2
Bomb Load	Type	—	—	—	—	500 lb
	Location	—	—	—	—	Centerline
	Number	—	—	—	—	1
Drop Tanks	Type	—	50 Imp gal	—	50 Imp gal	—
	Location	—	Centerline	—	Centerline	—
	Number	—	1	—	1	—

# OTHER AIRCRAFT

## *On The Western Front*

### ARADO AR 234 BLITZ

In October of 1944 the German staff squadron of KG 76 received the first new Arado Ar 234 Blitz "Lightnings," becoming the first air force in the world with operational turbojet bombers. Two earlier prototypes had arrived in France in July, and in early October operational reconnaissance missions were being flown over Allied areas of northwest Europe and even the British Isles. By November II, Gruppe/KG 76 had converted to the new aircraft, just in time to join the Ardennes counter-offensive in December. I Gruppe started its work-up in January, with III Gruppe following soon after.

The arrival of the B-1 reconnaissance Arados changed the situation for the Germans, providing good photo coverage of areas previously almost impossible to observe. Bombing missions began during the push through the Ardennes using B-2 bombers. But by March of 1945 these Ar 234 units had virtually ceased operations, after their vital opposition to the Allied crossing of the Rhine.

Despite its brief history above the battlefield, the Ar 234 began development in 1941, when the Arado Flugzeugwerke proposed and the Air Ministry accepted the E.370. The first prototype Ar 234 flew on 15 June 1943, and this design was to provide the Luftwaffe with a medium-range turbojet-powered reconnaissance aircraft which explored a number of advanced concepts.

The Ar 234 was an aerodynamically clean aircraft of all-metal stressed-skin construction with a tapered wing mounted on top of a slender fuselage. Two Junkers 004A turbojet engines were underslung below the wings. Powered by two Junkers Jumo 004A turbojets, it featured a pressurized cockpit and rocket-assisted takeoff (RATO) units to reduce its takeoff run.

The cockpit was roomy, comfortable and well laid out, the only drawback being the pilot's only escape via a roof hatch, since the entire nose was glazed in Plexiglas and no ejection seat was provided. Nonetheless, every pilot who flew the 234 had nothing but praise for its handling, although the take-off/landing gear provided endless trouble until early experiments with wheeled trolleys and skids gave way to a narrow-track (but conventional) landing gear by removing the center fuselage tank and making the front and rear tanks bigger.

Armament consisted of two rear-firing 20 mm MG 151 cannons, each fed with 200 rounds from an overhead magazine and aimed by the periscope over the cockpit. Since the 234 had ample speed to elude all attempts at interception by the RAF in its first reconnaissance operations over Britain, the inclusion of this extra weight is a curiosity. The 234 was most vulnerable in the vicinity of its airfield but handling was beautiful at all speeds and pilots would use speed rather than maneuvers to escape if intercepted. Crosswinds proved not to be a problem, but brakes did tend to burn out after two or three landings and engine failures were common.

For attack missions one 1,000 kg bomb could be carried under the fuselage and one 500 kg bomb under each jet nacelle, but since a heavy bomb load made the aircraft sluggish and reduced speed by 96 km/h (60 mph), 1,000 kg loads were normal.

Over two hundred Arado B-1 and B-2s were produced, and Ar 234C V6 and V8 prototypes with four engines were also tested in 1944. Other experiments such as the V16 with a crescent-shaped wing, the Deichselschlepp method of towing an auxiliary fuel tank, or the scheme of launching a flying bomb from the back of a 234C never got properly into production.

### AR 234B-2 DATA

<b>Engines</b>	Two 8.81 kN (1,980 lb st) Junkers Jumo 004B turbojets
<b>Wing Span</b>	14.11 m (46 ft 3.5 in)
<b>Length</b>	12.64 m (41 ft 5.5 in)
<b>Max T-O Weight</b>	9,850 kg (21,715 lb)
<b>Max Level Speed</b>	690-742 km/h (430-461 mph)
<b>Range</b>	1,630 km (1,015 mi)
<b>Armament</b>	Two rear-firing 20 mm cannon and up to 2,000 kg (4,410 lb) of bombs

### BOEING B-17 FLYING FORTRESS

Despite horrific losses, vast armadas of B-17s of the US 8th Air Force ranged far and wide over Germany and occupied Europe for three grueling years. Engaged in some of the largest and bloodiest air battles in all history, thousands of these bombers would blanket the sky in ribbons a mile wide and ten miles long. Bombing factories and strategic targets while whittling away at the fighter strength of the Luftwaffe, the Flying Fortress became the most well-known American bomber of World War II.

Ironically, this aircraft—which came to epitomize General ‘Billy’ Mitchell’s concept of strategic bombing—was conceived of in 1934 as a defensive weapon, intended by the Army as a multi-engined anti-ship bomber and ‘Flying Fortress’ to protect American shores against invading fleets. When

Boeing engineers interpreted 'multi-engined' as meaning four and not two engines, they achieved both greater height over their bombing targets and a significant advantage over rival design firms.

Boeing Model 299 was a prototype gamble which crashed during its first trial on 30 August 1935, but when investigations revealed someone had forgotten to remove the elevator locks, Boeing was given an order for 13 V1B-17 prototypes on 17 January 1936. Ultimately in 1938 the US Army ordered 39 production B-17Bs, the last ones entering service in March 1940. This immediately became the fastest, highest-flying bomber in the world, using the massed firepower of a large formation to render interception dangerous.

The B-17B—the first aircraft to enter service with turbocharged engines—also provided a higher maximum speed and much increased service ceiling. The RAF received 20 subsequent B-17Cs, and with the designation Fortress Mk I they were used operationally in Europe for evaluation. A disastrous initial career (nine survived) led to the improved B-17D and B-17E with revised armor, self-sealing tanks, and heavier defensive armament.

The B-17E added a much larger tail with a giant dorsal fin for better control and stability at high altitude, and armament was completely redesigned to give a powered turret behind the cockpit, a new turret in the tail, a pair of guns for the roof, and single guns at each waist position. With 10 heavy machine guns and two .30 caliber (7.62-mm) nose guns, 45 of this version were sent to the RAF as Fortress Mk IIAs.

The B-17F incorporated additional changes, allowing a potential bomb load for short ranges of 20,800 lb (9,435 kg), although a normal load seldom surpassed 5,000 lb (2,268 kg). But by far the most numerous model of B-17 was the B-17G (8,680), evolved from bitter combat experience to include a chin turret with twin .50 caliber (12.7-mm) guns and two more cheek guns to deter head-on attacks by German fighters. Operating by now at upwards of 35,000 ft (10,670 m), these bombers were so heavy their cruising speed fell to 182 mph (293 km/h), exposing gigantic Allied formations to even greater levels of German rocket and cannon fire.

Experimental variants included the B-40 with up to 30 guns/cannons, BQ-7 radio controlled pilotless aircraft packed with explosives, CB-17 and C-108 transports, and F-9 long range B-17s, equipped to serve as air-sea rescue aircraft and carrying a lifeboat beneath the fuselage.

In all a total of 12,731 Fortresses were built by the Boeing, Douglas, and Lockheed team, with captured B-17Gs even used by the clandestine Gruppe of the Luftwaffe to carry out daring operations throughout Europe and the Western Desert. They were not used for special covert operations; they were just better than any aircraft the Germans possessed.

### B-17G DATA

<b>Engines</b>	Four 1,200 hp (894 kW) Pratt & Whitney R-1820-97
<b>Wing Span</b>	103 ft 9 in (31.62 m)
<b>Length</b>	74 ft 4 in (22.66 m)
<b>Max T-O Weight</b>	65,500 lb (29,710 kg)
<b>Max Level Speed</b>	287 mph (462 km/h)
<b>Range</b>	2,000 mi (3,219 km)
<b>Armament</b>	Thirteen .50 caliber machine guns, plus bombs

### CONSOLIDATED B-24 LIBERATOR

Although the Flying Fortress was the better known American aircraft, the B-24 Liberator was the more versatile bomber. By war's end more of this aircraft had been built (18,188 versus 12,731 B-17s), flew longer ranges, carried more aircrew, attacked more shipping, and shot down more enemy fighters (2,600) than any other bomber in the Allied arsenal.

The Liberator became the Allies' best long-range bomber, making North Atlantic crossings routine, as Liberator I to IX versions were sent to the RAF Coastal and Bomber Command. 1942 versions attacked German U-boats who operated beyond the range of RAF fighters. And in Europe, Liberator formations attacked targets that could be reached no other way.

Consolidated Aircraft Corporation was given the go ahead by the US Army Air Corp in 1939 to push its superior wing design instead of merely becoming a second-source for B-17s. The design team had already achieved a better load/range performance than that of the B-17, creating a wide-span narrow-chord cantilever wing, mounted high on a deep-section fuselage.

Several additional innovations enhanced the conventional all-metal construction of the Liberator. A retractable tricycle-type landing gear was introduced for the first time. Bombs were stowed vertically in a two deep bomb bays—each carrying 4,000 lbs (1814 kg) of bombs—separated by a catwalk for crew access to the rear fuselage. Finally, instead of conventional bomb doors which affect flight characteristics, innovative doors rolled up the outside of the fuselage like a roll-top desk.

Prototype XB-24 first flew on 29 December 1939, by which time the US Army Air Corps had ordered seven for service trials, with others on order by Great Britain and France. The original prototype was re-engined with turbocharged Pratt & Whitney R-1830-41s, also having their oil coolers mounted on each side of the engine. These unusual elliptical cowlings combined with a stumpy fuselage and large twin oval endplate fins gave the Liberator an easily identifiable shape.

The first production B-24As were delivered to the USAAF in 1941. But these bombers did not come without a price. The B-24 was a complicated machine. It required extensive pilot training and was demanding to fly, even for fully qualified pilots. Liberators operated at such weights that takeoff became hazardous, even at full power. And in contrast with the durable B-17, Liberators were not able to take much punishment. In addition to vulnerability to head-on attack, the wing was relatively weak due to its complex construction, and could give way completely if hit in crucial places. Flight stability was also marginal, and escape from a crippled machine was difficult for the crew of seven once the pilot left the controls.

The majority of the first major production version of 2,700 B-24Ds, powered by R-1830-43 engines, went to the USAAF as bombers, with the US Navy taking many for anti-submarine warfare. 382 went to the RAF Bomber and Coastal Command as Liberator III/IIIAs and Vs. More than one-third of the total Liberator production, however, was the B-24J with R-1830-65 engines, supplied to US, British, Canadian, and other air forces.

The B-24 was best remembered in Europe for bombing Rome on 19 July 1943, and for their low-level attack by 177 aircraft on Romania's Ploesti oil refineries on 1 August 1943, a 2,700 mi (4,343 km) round-trip from Benghazi, Libya. The B-24 also flew in Africa and the Middle East, but its major contribution to America's wartime effort was in the Pacific, where in three years it dropped 635,000 tons of bombs and shot down 4,189 enemy aircraft.

## B-24D DATA

<b>Engines</b>	Four 1,200 hp (894 kW) Pratt & Whitney R-1830-65
<b>Wing Span</b>	110 ft 0 in (33.53 m)
<b>Length</b>	66 ft 4 in (20.22 m)
<b>Max T-O Weight</b>	60,000 lb (27,216 kg)
<b>Max Level Speed</b>	297 mph (478 km/h)
<b>Range</b>	1,540 mi (2,478 km)
<b>Armament</b>	Ten .50 caliber machine guns, plus up to 8,000 lb (3,629 kg) of bombs

## DOUGLAS C-47 SKYTRAIN

C-47s were so important to the US war effort that General Eisenhower considered them one of the four most significant weapons of World War II. This ubiquitous aircraft went by many names, from Skytrain and Skytrooper Dakota to Gooney Bird, but whatever it was nicknamed, the almost 11,000 C-47s that were manufactured by 1945 were always called dependable.

The first flight of the prototype DST, with 850-1,000 hp (633.4-745 kW) Wright Cyclone SGR-1820 engines, was made on 17 December 1935. It entered service with American Airlines on 25 June 1936, and transcontinental sleeper services started on 18 September. Orders for the DC-3/DST grew rapidly, with KLM becoming the first operator outside the US. In all, 800 DC-3s were produced before the war for the commercial airlines of the world.

In August 1936, while DC-3s were entering service for US domestic airlines, the US Army requested that changes in configuration be made to render it suitable for operation in a variety of military roles. In addition to more powerful engines, military requirements called for a strengthened rear fuselage, large cargo doors, and reinforcement of the cabin floor to enable it to carry heavy cargo loads.

When originally designed in 1934-35, many of the technical advances in landing gear, flaps, radial cowlings, propellers, and de-icer boots on the leading edges were all available off the shelf. The resulting C-47 had such versatility that the US armed forces ordered very large numbers, resulting in Douglas having built 10,654 civil and military variants by the time production ceased in 1947.

A C-47's exceptional service longevity was due to a fatigue-resistant structure, entirely of stressed skin and with a multi-spar wing. Its three man crew consisted of a pilot and co-pilot/navigator situated side by side with dual controls in a forward compartment, with a radio operator in a separate compartment. An automatic pilot control system was standard. But it was the all-important cabin which carried much of the Skytrain's potential. The C-47 Skytrain added large side doors, a reinforced floor with tie-down fittings, a glider tow attachment, folding wooden seats along the sides of the cabin, and racks and release mechanism for six parachute pack containers which were fitted under the fuselage.

The cargo compartment carried a maximum load of 6,000 lb (2722 kg), with pulley blocks for cargo handling, but alternative layouts could provide for the transport of 28 fully-armed paratroopers, or for 18 stretchers and a medical team of three. In the troop transport role, Skytroopers—also redesignated as Dakota Mk I by the RAF—served during such operations as the airborne invasion of Burma and the D-Day invasion where more than 1,000 Allied C-47s were involved, carrying paratroops and towing gliders laden with paratroops and supplies. In fewer than 60 hours, these workhorses airlifted more than 60,000 paratroops and their equipment to Normandy.

## C-47A DATA

<b>Engines</b>	two 1,050 hp(782 kW) Pratt and Whitney R-1830-92
<b>Wing Span</b>	95 ft 0 in (28.96 m)
<b>Length</b>	64 ft 5 in (19.63 m)
<b>Max T-O Weight</b>	28,000 lb (12,701 kg)
<b>Cruising Speed</b>	170 mph (274 km/h)
<b>Range</b>	1,025 mi (1,650 km)

## HEINKEL HE 111

At the time of the Luftwaffe's secret birth in the 1930s, many German aircraft were being designed which could be rapidly adapted from civilian to military roles. Bombers assumed great importance in this massive expansion program, with the twin-engine He 111 designed to be a fast airliner which could be easily converted to carry bombs.

The first prototype of this dual-purpose aircraft—a low-wing, all-metal monoplane powered by two 447 kW (600 hp) BMW VI inline engines—first flew on 24 February 1935. This clean-looking prototype featured semi-elliptical wings fitted with hydraulically operated trailing-edge flaps and hydraulically actuated retractable landing gear. In a bomber configuration, it was armed with three machine guns in the nose, dorsal, and ventral positions, and was able to accommodate an internal bomb load of 1,000 kg (2,205 lb).

Six He 111C-0s, introduced as civil airliners with accommodation for ten passengers, entered service with Lufthansa during 1936, and were given the full glare of press publicity. They were evaluated, but, because of inadequate engine power, were rejected, and all 10 original versions were sold to China.

By the third prototype—which was a genuine forerunner of the He 111A series bomber—the aircraft showed itself to possess a performance better than many then-current fighters. Subsequently, the Luftwaffe used this aircraft for secret high-altitude reconnaissance missions, many occurring prior to the outbreak of war, by both military and civilian aircraft. These flights gave the Luftwaffe detailed information about a vast number of targets before the first wartime missions were flown.

While the first He 111B-1 production bombers were entering Luftwaffe service in late 1936, thirty were also shipped to Spain to be tested in the Civil War. Their superior performance against opposing fighters allowed these early Heinkels to operate unescorted. Such tactics were to prove costly over Britain against Hurricanes and Spitfires, relegating He 111s to the safer but less accurate role of a night bomber, and leading to more heavily armed versions, many with a 20mm cannon and as many as seven machine guns.

705 Heinkel bombers were launched against Poland in the war's first campaign, first raiding far beyond the front line and ultimately launching devastating raids on Warsaw. Eight months later, Heinkels were employed in the Norwegian campaign and also in attacks on Rotterdam. At the beginning of the Battle of Britain, He 111s, with a top speed of 435-km/h (270-mph), proved difficult to shoot down. But despite being capable of withstanding heavy battle damage, they needed large numbers of escorting fighters to withstand the RAF. The 17 *Gruppen*, which operated 500 Heinkels during that battle, lost 246 of their number in air combat over a four month period. This battle marked the decline of the Heinkel as a strategic weapon.

The He 111H was the most extensively built version with more than 5,000 constructed before production ended in 1944. It was powered by two Junkers Jumo engines, with power ranging from 752.6 kW (1,010 hp) for the Jumo 221A to 1,323.5 kW (1,776 hp) in the Jumo 213A-1s, which were installed in the He 111H-23 paratroop carrier. These latter versions carried 16 paratroops such as dropped behind American lines at the beginning of the Ardennes campaign.

Continually modified throughout World War II, various versions of the He 111 included torpedo-bombers, pathfinders, transports for cargo, glider tugs, launch platforms for Hs 293 and Frieseler Fe 103 flying-bombs, and even in a 'twinned' version as a five-engined He 111Z Zwillling, designed to tow huge Messerschmitt Me 321 Gigant ("Giant") gliders or carry four Henschel Hs 293A rocket bombs over long distances.

### HE 111H-16 DATA

<b>Engines</b>	Two 1,006 kW (1,350 hp) Junkers Jumo 211F-2s
<b>Wing Span</b>	22.6 m (74 ft 1.75 in)
<b>Length</b>	16.4 m (53 ft 9.75 in)
<b>Max T-O Weight</b>	14,000 kg (30,865 lb)
<b>Max Level Speed</b>	435 km/h (270 mph)
<b>Range</b>	1,950 km (1,212 mi)
<b>Armament</b>	One 13 mm MG 131, one MG 81 twin-gun, one MG FF cannon, plus a bomb load of up to 2,000 kg (4,409 lb)

## JUNKERS JU 88

The Ju 88 was a distinctive aircraft, with a large 'insect-eye' nose and the ability to adapt to virtually every role Germany demanded. With the exception of close dogfighting, the Ju 88 excelled in a variety of roles: dive bomber, night fighter, tank buster, anti-shipping platform, and pathfinder. Eventually production of the Luftwaffe's workhorse totaled 14,980 aircraft.

According to the requirements of the German air ministry, they needed a fast bomber which could fly at 500 km/h (311 mph) and carry a bomb load of 800 kg (1,765 lb). Junkers aggressively took the challenge, even hiring two American designers who pioneered advanced stressed-skin structures in the USA. The Ju 88 V1 prototype was first flown on 21 December 1936 and by 1939 approximately 50 were in service. The Americans were never credited.

The engine of the Ju 88A-1 was the 895-kW (1,200-hp) Jumo 211B-1, one of the classic Junkers series of inverted-Vee 12-cylinder powerplants with direct fuel injection. The engines hung on two giant magnesium alloy forging beams, resulting in unusually long nacelles and causing the Ju 88 to be known as *die Dreifinger* (the three-finger). Designed for tactical warfare, normal fuel capacity was only 1,677 litres (369 Imp gal), although the bomb bays often held extra tanks, bringing the total up to 3,575 litres (786.4 Imp gal).

The number of Ju 88 prototypes and development aircraft were in excess of 100, about ten times the production run of modern aircraft. The Ju 88A-1 was armed with four 7.9 mm MG 15 machine guns and carried 2,500 kg (5,511 lb) of bombs. The A-2 was specially fitted for catapult-assisted take-off; the A-3 trainer had dual controls; the A-4 had an increased wing span of 20 m (65 ft 8 in), and was typically armed with one 13 mm MG 131, five 7.9 mm MG 81 machine guns and 3,000 kg (6,614 lb) of bombs.

From mid-1940, all Ju 88 bombers were based on the long-span JU 88A-4, which provided better handling, no structural limitations, a streamlined four man crew compartment, and powerful Jumo 211J engines. During the Battle of Britain Ju 88s were able to evade even a Spitfire by diving. Nonetheless they suffered heavy losses to RAF fighters, though incurring significantly lower attrition than other German bombers. Ju 88s were armed with at least 40 different schemes, but most later bombers used the light and fast-firing 7.92-mm (0.31-in) MG 81, often used in pairs, and combined with 13-mm (0.51-in) MG 131s.

The Ju 88G was produced as a night fighter with SN-2 radar and the distinctive *Hirschgeweih* (Stag's Antlers) radar array, able to operate even in the face of chaff. In the spring of 1944 RAF heavy bombers, which emitted up to three sets of radar signals, were being cut down in droves by these German night fighters. Had they appeared earlier in the war they would have posed a serious threat, but they arrived in mid-1944 as output was falling, never to exceed 800.

As the war progressed, early Ju 88 variants were relegated to second-line duties, such as providing a testbed for the BMW 003 jet engine, and by war's end the Ju 88A-4 was combined with a Messerschmitt Bf 109f or Fw 190 to create a *Mistel* (mistletoe) conversion, using the fighter to remotely guide the Ju 88 carrying a massive 3800-kg (8,378-lb) warhead toward Allied shipping. Unfortunately, these excessive loads burst tires and caused a number of disastrous take-off accidents.

### JU 88A-4 DATA

<b>Engines</b>	Two 998.5 kW (1,340 hp) Junkers Jumo 211Js
<b>Wing Span</b>	20 m (65 ft 8 in)
<b>Length</b>	14.3 m (47 ft 1.5 in)
<b>Max T-O Weight</b>	14,000 kg (30,865 lb)
<b>Max Level Speed</b>	470 km/h (292 mph)
<b>Range</b>	2,500 km (1,553 mi)

### MARTIN B-26 MARAUDER

In May 1943, the Marauder began its career as the primary medium bomber in the European theater. It was boldly selected for its wing design which was optimized for high-speed cruise efficiency. Rushed into service without prototypes, the Marauder still achieved the lowest loss rate of any US Army bomber in Europe.

With the US Army Air Corp poorly equipped with medium bombers, design data for the Model 179 Medium Bomber was accepted by the US Army Air Corps on 5 July 1939 and the first Marauder flew sixteen months later. By 25 February 1941, the Marauder was in production, and by the end of 1944, more than 5,150 had been delivered. A total of 139 B-26As were moved to Australia immediately after Pearl Harbor in December 1941. In June of 1942, torpedo-carrying Marauders went into action during the Battle of Midway.

Two 1,850 hp (1,378.6 kW) Pratt & Whitney R-2800-5 radial engines powered the sleek production version which carried a defensive armament of five .50 caliber machine guns in nose, dorsal, and tail turrets. The wing was mounted shoulder-high, leaving almost the whole mid-fuselage as a bomb bay. Tandem bays held 2,000 lb (907 kg) of bombs, but up to 5,800 lb (2,631 kg) could be accommodated in the relatively large, unpressurized fuselage.

In May 1942 the B-26B first appeared, becoming the most-produced version with 1,883 units built. The B-26B-1 provided increased armor protection, a ventral gun position, and tail armament increased to two guns. As weight increased, later B-2 through B-4 versions were upgraded to 2,000 hp (1490.4 kW) Rk-2800-41/-43 engines.

All of this rapid innovation did not come without a price, however. Upon its entry into service the Marauder had the highest wing loading of any aircraft then designed for the USAAF. With this wing loading came a high landing speed, the B-26 having a normal touch-down speed of 103 mph (166 km/h). Maintaining crew confidence was difficult because of the dangerous landing speeds, and conversion training was lengthy. Eventually the wing and vertical tail were extended to make it easier to fly.

To reduce the wing loading, in the B-10 version (Marauder II) the wing span was increased from 65 ft (19.81 m) to 71 ft (21.64 m) and the area of the vertical tail surfaces was also increased to improve lateral stability and limit touchdown speed. In addition, four 0.5-in (12.7-mm) 'package' machine-guns and a Martin-Bell power-operated tail turret was included, and crew was increased from five to seven. The B-26C (Marauder II) was the same as the B-26B-10 block. These 1,235 bombers were built at the Martin plant in Omaha, Nebraska.

Early wartime operations in northern Europe by the B-26 were disappointing. An attack in May 1943 resulted in the loss of an entire formation to flak, German fighters and collision. Operations moved to medium and high altitudes, and by the end of 1943, the newly formed 9th Air Force was providing the Marauders with fighter escort and using them effectively in the role of medium-altitude strategic attack bombers in preparation for the upcoming invasion of Europe.

Despite problems stemming from the relatively advanced design, the B-26 had an impressive record, providing 129,943 operational sorties in the European and Mediterranean theaters alone, and dropping 169,382 tons of bombs. Their crews destroyed 402 enemy aircraft while losing 91 aircraft themselves, to represent an overall loss rate of less than one per cent.

### **B-26B/C DATA**

<b>Engines</b>	Two 1,920 hp (1,432 kW) Pratt and Whitney R-2800-43
<b>Wing Span</b>	71 ft 0 in (21.64 m)
<b>Length</b>	58 ft 3 in (17.75 m)
<b>Max T-O Weight</b>	38,200 lb (17,327 kg)
<b>Max Level Speed</b>	287 mph (462 km/h)
<b>Range</b>	1,200 mi (1,931 km)

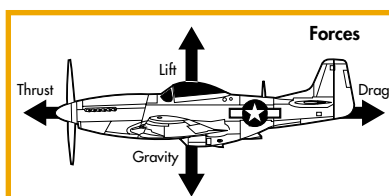
# THE BASICS OF *Flight*

All maneuvers make use of one or more vectors of movement—pitch, yaw and roll. To initiate these movements, you use the aircraft's control surfaces. The rudder, elevators and ailerons cause the actions listed below.

This section discusses the forces at work behind flight and describes how to use the aircraft's flight controls to create movement.

## PHYSICS

The miracle of flight exists because man has the technology to oppose natural forces that keep all objects on the ground. Four forces affect an aircraft—two assist flight (thrust and lift), and two resist flight (gravity and drag). The important thing to note here is that when an aircraft is flying straight and level, all four of these forces are balanced, or in equilibrium.

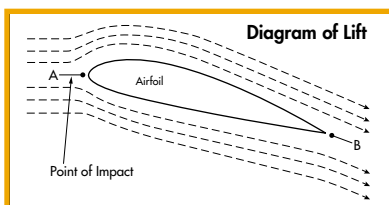


## THRUST

*Thrust* is created by the engines. As propeller blades push air through the engine (or as jet fuel is combusted to accomplish the same end), the aircraft moves forward. As the wings cut through the air in front of the aircraft, *lift* is created. This is the force that pushes an aircraft up into the air.

## LIFT

Lift occurs because air flows both over and under the surface of the wing. The wing is designed so that the top surface is "longer" than the bottom surface in any given cross-section. In other words, the distance between points **A** to **B** is greater along the top of the wing than under it. The air moving over the wing must travel from **A** to **B** in the same amount of time. Therefore, the air is moving faster along the top of the wing.



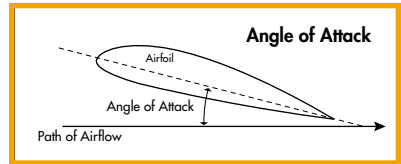
This creates a difference in air pressure above and below—a phenomenon called the *Bernoulli effect*. The pressure pushing up is greater than the downward pressure, and lift is created. If you're banking, lift occurs in a slightly sideways direction. If you're inverted, lift actually pulls you downward

toward the ground. Note that lift occurs perpendicular to a line drawn parallel to the centerline of the wing and occurs at a slightly backward angle.

Several factors determine how much lift is created. First, consider the angle at which the wing hits the air. This is called the *angle of attack*, which is independent of the aircraft's flight path vector. The steeper this angle, the more lift occurs. At angles steeper than 30° or so, however, airflow is disrupted, and an aircraft *stall* occurs. During a stall, no lift is created. The aircraft falls into a dive and can recover lift only after gaining airspeed.

## DRAG

*Drag* opposes thrust. Although it mainly occurs because of air resistance as air flows around the wing, several different types of drag exist. Drag is mainly created by simple skin friction as air molecules “stick” to the wing's surface. Smoother surfaces incur less drag, while bulky structures create additional drag.



Some drag has nothing to do with air resistance and is actually a secondary result of lift. Because lift angles backward slightly, it has both an upward, vertical force and a horizontal, rearward force. The rearward component is drag. Another type of drag is induced at speeds near Mach 1, when a pressure differential starts building up between the front and rear surface of the airfoil. The pressure in front of the wing is greater than the pressure behind the wing, which creates a net force that opposes thrust. In WW II aircraft, this last type of drag occurred only during prolonged dives.

## GRAVITY

*Gravity* is actually a force of acceleration on an object. The Earth exerts this natural force on all objects. Being a constant force, it always acts in the same direction: downward. Thrust creates lift to counteract gravity. In order for an aircraft to take off, enough lift must be created to overcome the force of gravity pushing down on the aircraft.

Related to gravity are G-forces—artificially created forces that are measured in units equivalent to the force of gravity. See *G-Forces* for details.

## G-Force

A “G” is a measurement of force that is equal to the force of gravity pushing down on a stationary object on the earth's surface. Gravitational force actually refers to an object's weight (Force equals Mass times Acceleration, or  $F = ma$ ). An aircraft flying level at low altitudes experiences 1G. Extra G-forces in any direction can be artificially created by sudden changes in velocity or in the direction of motion. Good examples are a takeoff, a tight turn in an aircraft at moderate to high speed or a loop maneuver.

G-forces can be either positive or negative. *Positive Gs* make you feel heavier because they act in a relative downward direction. They push you back into your seat and primarily occur during sharp turns or steep climbs. *Negative Gs* make you feel lighter because they're pulling in a relative upward direction. When you're in a steep dive, they pull you out of your seat. The direction of G-forces is always relative to the position of the aircraft—if you're flying upside-down, upward Gs actually pull in a downward direction.

### Apparent Weight

*Apparent weight* refers to how heavy something seems considering the current direction and magnitude of G-forces acting on it. In level flight, 1G is acting on the aircraft and the pilot—both weigh the same as they do when stationary. If the pilot makes a steep climb, the positive G-force temporarily acts on both the pilot and the aircraft, making them in essence heavier throughout the climb. Any sudden increase or decrease in acceleration brings about a change in apparent weight of an object.

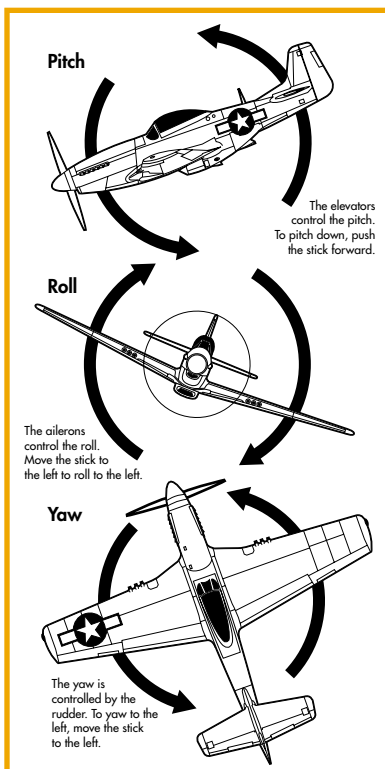
### Physical Effects of G-Forces

Human bodies can withstand approximately 9 or 10 positive Gs or 2 to 3 negative Gs for several seconds at a time. Exceeding positive G limits for longer than that causes blood to collect in the lower part of the body and torso. The brain and retinas receive less blood, and therefore less oxygen. Eventually, vision turns gray, followed by tunnel vision and pilot blackout. Excessive negative Gs have a similar effect, except that blood pools in the brain and upper torso. This causes the small capillaries in the eyes to swell, creating a redout effect.

## MOVEMENT VECTORS

*Pitch* is the up and down movement of the aircraft's nose around an axis line drawn from wingtip to wingtip. When you apply pitch by pulling back on the stick, you angle the aircraft's elevators up, causing the nose to rise.

*Yaw* is the side-to-side rotation of the aircraft's nose around a vertical axis through the center of the aircraft. It changes the direction of horizontal flight, but does not affect altitude.



You use the rudder to angle the aircraft's rudder left or right, which creates yaw.

*Roll* is the tipping of the wings up or down. The aircraft maintains its current direction of flight, but the wings spin around an imaginary line drawn from the nose through the tail. Roll occurs when you push the stick left or right, causing one aileron to angle down and the other to angle up. This increases lift under one wingtip while decreasing lift under the other, creating roll.

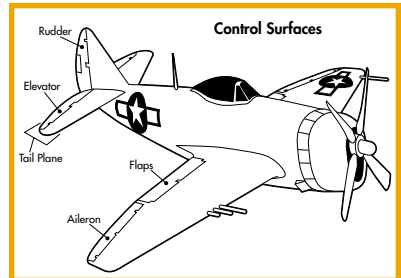
## BANK

You can combine pitch and roll movements to make a banking turn. By pitching the nose up and applying right stick, you cause the aircraft to bank to the right. You can accomplish a left bank by pitching up and applying left stick. A banking turn changes both the angle of the nose and the direction of flight.

One side-effect of a banked turn is that you lose both lift and airspeed. If you want to preserve your altitude and energy, it's always a good idea to apply a bit of extra throttle preceding a bank turn.

## CONTROL SURFACES

All control surfaces utilize the principle of lift, but they apply lift forces in different directions. These forces act either independently or in conjunction with one another to produce various maneuvers. Each maneuver is the net resultant force of all individual forces. (A resultant force is the average force that results when two forces are combined. For example, a pure vertical force and a pure horizontal force create an angled force.)



## ELEVATORS

Elevators are flat, hinged surfaces on the tailplane (the horizontal part of the tail assembly). While the entire tailplane surface helps stabilize the aircraft during flight, the elevators apply pitch by angling the trailing (rear) edge of the tailplane up or down.

To create pitch, gently pull the flight stick back or push it forward. Take care not to perform pitch maneuvers too quickly. If the angle of attack (angle that the air meets the wing) becomes too steep, the flow of air around the wings can become disrupted. Air no longer flows smoothly over the wing; instead, it buffets in several different directions and disrupts the air pressure around the wing's surface. This situation is called a *stall*.

Stalls can also occur from lack of airspeed, when not enough air flows over the wings to create lift. This is commonly encountered in propeller-powered aircraft, especially during steep climbs in which gravity reduces airspeed. Note that climbing steeply is not the same thing as pitching up too quickly. The former type of stall is caused by lack of airspeed, while the second type is due to disrupted airflow around the wing. See **Stalls** for more information.

### RUDDERS

The rudder is the vertical component of the tail assembly. The rear half of the vertical tail section is hinged, allowing it to angle left or right. When you apply rudder, you redirect the aircraft's nose either left or right.

Applying left rudder yaws the nose to the left, while applying right rudder veers the nose to the right. Note that applying rudder also produces a very slight rolling movement, which can be negated by pushing the stick in the opposite direction.

### AILERONS

Ailerons are thin, hinged surfaces on the outer, trailing edge of each wing. They angle in opposite directions to waggle the wings up and down or roll the aircraft about its nose-tail axis. If you apply stick left or right, one wing's aileron angles down and the other angles up. This rolls one wing up and forces the other wing down, effectively rolling the airplane.

When you apply left stick, the left aileron raises and the right one drops, and the aircraft rolls to the left. The opposite occurs if you push the stick in the opposite direction.

### FLAPS

Similar to ailerons, flaps are thin, hinged surfaces on the trailing edge of the wing. However, they are located nearer to the wing root than ailerons and operate in tandem. (If one flap is lowered or raised, so is the other.) A raised flap conforms to the wing's natural shape. A lowered flap alters the airflow around the wing, effectively changing the wing's aerodynamic shape and increasing the amount of available lift.

You extend flaps during takeoff to gain additional lift, then retract them during flight to maximize your airspeed. While flaps increase your aircraft's angle of attack, they also increase drag. In a pinch, you can use flaps while chopping the throttle to quickly reduce your airspeed.

One point to note is that flaps can only be extended at low to medium speeds. If the aircraft is traveling too fast, air flows too fast over the flaps, and they cause drag. In high-speed dives, flaps and other control surfaces may become unusable—air travels so fast over them that you can't move them until you slow down the aircraft.

## COMPRESSIBILITY

Compressibility is a condition that renders an aircraft's control surfaces inoperable. It occurs at very high speeds, such as those attained during a long, steep dive. Air that flows around the airfoil surface separates into two directions at some point in front of each wing. This is called the *point of impact*. At higher speeds, this point moves further and further in front of the wing and creates pressure disturbances on and around the wing. As an aircraft's speed approaches Mach 1, the speed of the air flowing over the wings reaches the speed of sound before the aircraft does. Remember, air flows faster over the top of the wing and is actually traveling faster than the aircraft at any given point in time.

Pressure waves generated by the movement of wings through the air act much like ripples on a pond. They radiate outward and “warn” the yet undisturbed air molecules in the path of the approaching wing. As the aircraft's speed approaches Mach 1, these pressure waves pile up in front of the wing. (The Mach number is the aircraft's speed divided by the speed of sound for the current altitude and temperature.)

At some point, the wing is traveling so fast that the waves no longer radiate ahead of the wing. This creates shock waves and causes the aircraft to buffet. Aileron and elevator controls mounted on the wing and tail surfaces freeze up due to excessive pressure, or act in directions opposite than normal. The phenomenon of compressibility occurs only at very high speeds. The only remedy in WW II aircraft is to chop the throttle and attempt to pull out before it's too late. If you don't react quickly enough, your control surfaces may freeze and you could crash.

## BASIC FLIGHT MANEUVERS

This section covers the basics of flight—takeoff, climbing, descending and landing—and outlines basic recovery procedures for stalls, a common occurrence.

### TAKEOFF

Taking off from an airfield is a fairly straightforward procedure. First, lower the flaps to change the aerodynamic shape of the wing, and then apply full throttle.

Once you generate enough forward airspeed and lift, the tailwheel (if the aircraft has one) rises off of the runway surface. Gently apply rear stick to pitch the nose up approximately 10°. Be careful not to climb too steeply—if your airspeed starts falling, you'll need to reduce the pitch angle to avoid stalling. (For corresponding keyboard commands, see the accompanying *Gameplay Guide* or *Keyboard Reference*.)

1. Lower flaps
2. Increase throttle to 100%
3. Wait until your speed is over 100 mph (160 km/h). (Exact airspeeds for takeoff vary by airplane). Gently apply pitch (pull back on flight stick) so that your climb attitude is around 5°
4. Keep pitch steady (if airspeed drops, reduce pitch)

---

**Note:** You can take off automatically by using the game's autopilot feature. See the *Gameplay Guide* for details.

---

### CLIMBING

After you take off, the next step is to retract the landing gear—it creates unnecessary drag, and once you're airborne it's important that you reduce drag in order to build up speed.

Keep your throttle on its full setting, and pitch the nose slightly upward until it's at about a 20° angle. If you start to lose airspeed or if the STALL warning appears onscreen, dip the nose down until you're again flying level. Then, resume climbing at a gentler angle.

As long as no approaching aircraft are in your flight path, you can maintain this climbing position until you reach the desired altitude. You can also angle gently toward your first waypoint, although turning will sacrifice some airspeed and lift.

Once you decide you're ready to level out, reduce the throttle until you slow down to the desired cruising speed (flying on full throttle quickly consumes fuel, and you might not have enough to make the return trip home). Make slight adjustments to the throttle setting until you're flying at a constant speed and altitude.

1. Retract landing gear
2. Maintain full throttle
3. Pitch upward at a 20-degree angle
4. Level out
5. Reduce throttle to desired airspeed
6. Make slight throttle adjustments until you have a constant speed and altitude

## DESCENDING/DIVING

There are two methods by which you can reduce your altitude. First, you can reduce your throttle setting, which creates less lift and therefore drops your altitude. If you aren't particularly concerned with getting down in a hurry, this method is fine. You maintain level flight without losing noticeable airspeed (although you reduce the throttle, your aircraft gains some speed while descending due to gravity).

The second method is to redirect the nose by pitching down. This is the more drastic method—you bleed off altitude in a hurry and gain airspeed. The dive is often used to attack a lower-flying aircraft or as a recovery procedure following a stall.

Be wary of prolonged dives or extremely steep dives at low altitude—your aircraft's controls may “freeze” due to compressibility (air moves so quickly over the control surfaces that they're rendered useless).

- ★ Decrease throttle to slowly lose altitude at the current airspeed
- ★ Alternatively, pitch down to descend quickly and gain airspeed

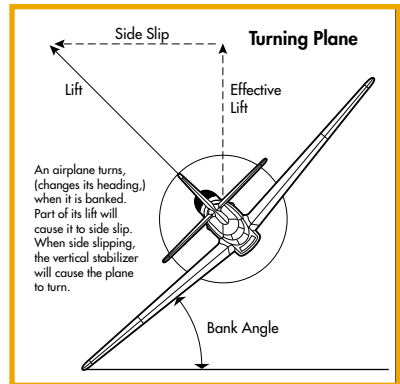
## BANKED TURNS

Turning is also known as banking, or combining pitch and roll maneuvers to alter your heading. By pulling the stick back and either left or right, you make a banked turn. You can also apply rudder in the intended direction of the turn to make the turn more quickly.

If you enter a banked turn without adjusting the throttle, you lose altitude, airspeed, or both by the time you finish turning. This occurs for two reasons. First, you change the angle of attack (angle of the wings as they meet the airflow). This creates drag that slows down the aircraft. Secondly, lift acts nearly perpendicular to your aircraft's wings. If the wings are angled, so is the lift vector. You have less pure vertical force, so you drop in altitude.

If you want to maintain altitude and speed, apply extra throttle before you start banking.

- ★ Push stick left or right to bank the airplane.
- ★ Pull back on the stick to begin the turn.



### LANDING

Landing *sounds* simple—you reorient your aircraft's nose so that it's pointing in the general direction of the airfield, bleed off some speed and altitude, lower the gear, and touch down. But in reality, many factors affect whether you land an aircraft safely or convert it into a junk pile.

Landing takes a steady hand and a smooth series of changes in throttle and pitch. When you're ready to land, you need a range of at least 3 miles from the airfield. Make sure you are flying level at about 500 ft of altitude and that your throttle is set to about three-quarter speed. Drop the gear and lower the flaps—with flaps, you have more lift and can slow down without going into a stall. Gently pitch down to start your descent, striving for a maximum airspeed of about 120 mph (193 km/h).

Once the aircraft reaches the edge of the runway, you should have between 20 and 30 feet (6 to 9 meters) of altitude. Pull the stick back firmly to raise the nose up past the horizon and chop the throttle to zero. The main wheels will touch down. As your skills progress, you may even touch down all of the aircraft's tires simultaneously.

1. Line up with the runway 3 miles out
2. Fly level at 500 ft (152 meters) of altitude
3. Reduce speed until you're below 120 mph (193 km/h)
4. Lower the landing flaps
5. Lower the landing gear
6. Gently pitch down
7. Reduce airspeed even further
8. At the edge of the runway, with 20 to 30 feet (6 to 9 meters) of altitude, pitch the nose up 15°
9. Cut the throttle to zero

### STALLS

A *stall* is the loss of lift. They occur because your aircraft's speed has dropped below the airspeed required to maintain lift. Without lift, your aircraft falls toward the ground and your control surfaces are useless, much like a sail without a breeze to propel it. Stalls are most commonly experienced during tight turns, steep climbs, loops, or takeoffs and landings.

To solve a stall situation, let the aircraft fall and try to keep the nose oriented toward the ground (most aircraft nose down automatically). Make sure the throttle is set at 100%. Eventually, this buys enough airspeed to restore airflow over the control surfaces and let you regain control of your aircraft.

- ★ Let the aircraft fall to regain airspeed, then slowly level out when controls respond
- ★ Increase throttle to 100% if it is currently lower
- ★ Alternatively, increase throttle to regain airspeed

## SPINS

A spin is a special type of stall that happens when one wing loses lift, but the other does not. More often than not, a spin occurs when you make a hard turn and have the nose pitched too steeply. Lift fails on one wing, and it begins to drop toward the ground. Meanwhile, the opposing wing keeps producing lift and rising. If the rudder is engaged, it rotates the aircraft about its yaw axis. The result is a spinning corkscrew motion.

All aircraft have a critical angle of attack, or a maximum angle at which the wings can still provide lift. If you nose up drastically at high speeds, you may surpass this angle and initiate a stall or spin.

To recover from a spin, you have to neutralize the aircraft's rotating motion. The best way to accomplish this is to center the stick and apply rudder in the opposite direction of the spin. Then, nose the plane downward. Hopefully, you'll have enough altitude to recover and break out of the spin.

- ★ Restore stick to center position
- ★ Apply rudder opposite the spin (if you're spinning left, apply right rudder)
- ★ Pitch down
- ★ When you stop spinning, level out

## COMBAT

Fighters and bombers exist for one, simple reason—to destroy other enemy aircraft and ground targets. Over the last half-century, the evolution of aircraft and weapons built to accomplish this purpose has been swift and effectual. Even before the start of the Second World War, it became evident that the outcome of all future conflicts would be largely determined by who could maintain air superiority. Each side's goal was to ensure that friendly aircraft could freely patrol the skies over critical areas, while denying that same privilege to the enemy. Whoever controlled the skies had a distinct advantage—that power could wage strategic bombing attacks, supply and support front-line forces, conduct reconnaissance efforts and suppress enemy advances.

With aircraft now a primary tool of war, World War II became a deadly laboratory for aerial combat technique. The fighters built in the 1930s and 1940s were faster, tougher and more threatening than the biplanes of the past and necessitated new combat techniques. Pilots developed distinct methods of fighting built upon experience instead of theory, and many of their time-tested strategies survive today in combat aviation schools around the world.

Combat can be offensive or defensive in nature, thoroughly planned or spontaneous, victorious or unsuccessful. Much of what occurs in the air has to do with training, but just as often, depends upon a pilot's instincts. To be an outstanding combat pilot, you must have a good understanding of the basics and possess inherent talent. Know every trick in the book, and then keep a few extra ones up your sleeve for moments when unconventional tactics could very well save your life.

### AIR-TO-AIR COMBAT

Most people think of combat as simply trading shots with an enemy, but the actual process involves much more than that. First, you must travel safely to the sphere of action. Then, you must detect the enemy and assess the situation. What kind of aircraft is he flying? What are his weapons capabilities? Performance characteristics? Will this be a speed fight, a turning fight, or should you save combat for another day and return to base? All things considered, you must then maneuver into the most advantageous position possible before actually firing your weapons.

Combat has several distinct phases. These phases do not necessarily occur linearly. In fact, combat is most often an ever-changing mix of the five:

1. Detecting an enemy
2. Positioning for an attack
3. Maneuvering during combat
4. Firing weapons
5. Defending during an attack

Oswald Boelcke, an outstanding WW I fighter pilot and perhaps the best unit leader of the war, neatly summarized the fundamental tactical rules for dogfighting. His eight commandments for fighter pilots, known as Boelcke's Dicta, are rephrased here:

- ★ Take any advantages you can before you start an attack. Gain altitude and keep the sun behind you to blind your target.
- ★ After you commit to starting an attack, make sure you finish it.

- ★ Stick to close-range shots, and don't fire until you have the enemy well-lined up in your sights.
- ★ Constantly know where your opponent is. Don't glance away and let him fool you with his maneuvers.
- ★ Make your attack from behind if you can.
- ★ If an enemy is making a diving attack on you, don't evade it. Instead, try climbing up to meet him.
- ★ When flying over enemy territory, remain aware of your escape route toward friendly lines.
- ★ Attack in numbers. If all pilots separate into individual battles, communicate and make sure no one is making a duplicate attack.

## DETECTING THE ENEMY

Before you can fire on a foe, you must use all the methods at your disposal to detect him. Conversely, you don't want him to detect you first. It's much harder to keep an eye on all 360 degrees when you're flying alone, so keep your wingman close by until it's time to break formation and enter combat.

### Vision

Successful fighter pilots all have two traits in common—good eyesight and a keen sense of awareness of the combat environment. Before the advent of modern radar, the only real tool that a pilot had to work with was his own eyesight. Midway through World War II, radar was in still in its infant stages. Few aircraft had access to radar, so the key to winning an aerial bout was to gain a good visual mark on your target.

Later in an encounter, eyesight also plays an important role in tracking a target with your guns and in training bullets so that they cross your enemy's flight path.

The detection phase is perhaps the most critical element of combat. If you exercise every means of detection and find the enemy before the enemy finds you, you'll have the element of surprise on your side.

### Alter Your Viewpoint

Keep in mind that the cockpits of some aircraft obscure your vision (e.g., the Bf 109). The best way to surmount this problem is to constantly alter your flight path so you have a full view of your surroundings. If you suspect the enemy is lurking in the area, try weaving left to right. Check the area over your left shoulder as you weave left, over the right shoulder and you weave right. Then, invert your aircraft by rolling over and flying upside momentarily to scan the lower hemisphere of your view. You can also pitch slightly upward or downward to check above and below for enemies.

You can use these tactics while flying alone, or while flying with a wingman. In an ideal situation, you'll have at least one additional body in the air. You can use the buddy system to watch out for one another.

Although these methods may not always prevent an attack on your aircraft, they can help keep you aware of the combat environment.

### **Use Your Wingman**

In combat expeditions, your wingman is an invaluable resource. By sharing the duty of scanning the skies, you both are able to watch out for one another. During multiplayer play, one of the best skywatching methods you can use is for you and your wingman to both occasionally fly an alternate weave patterns—just avoid colliding with him.

The advantage of this system is that you can constantly cover each other's blind spots.

## **POSITIONING**

Two tenets of combat should be ingrained so thoroughly in your mind that you can recite them instantaneously and under any condition:

**Surprise is your supreme advantage:** If your enemy hasn't seen you, you can carefully maneuver into a good firing position.

**Altitude is energy:** The higher you are, the more energy (and speed) you have to work with.

Any successful pilot knows these by heart and practices them constantly. Most of the successful attacks made by WW II fighters were attacks that caught the enemy off-guard. Of these, most were made from the rear quarters.

### **Use the Sun**

Tested both by the trials of time and thousands of pilots, the age-old trick of hiding in the sun works. If you position yourself along an imaginary line between the sun and the aircraft you're attacking, chances are you won't be spotted. The technological development of radar has rendered this tactic practically obsolete for today's jet fighters, but with WW II aircraft, you can still put bright, sunny days to good use.

In the game, use your aircraft's external views to find the sun, and place yourself between the sun and your enemy. Then, make a beeline attack for him.

### **Use the Clouds**

You can also use clouds to cover your approach or make your exit. Of course, the disadvantage of cloud cover is that you may be the victim of an enemy attack from the clouds above.

## Approach High

Altitude takes advantage of the fundamental rules of energy. *Potential energy* (stored in the form of altitude) can easily be converted into *kinetic energy* (airspeed) by diving. Whichever pilot has the most speed holds the initiative. He can choose to press the attack or break it off if the situation is unfavorable.

## Attack from the Rear

Whether or not you've been spotted, if you're behind the aircraft you're attacking, you have a positional advantage. The pilot in front of you must look forward while flying and rely on quick, rearward glances to keep track of your approach. He'll likely spend most of his time trying to evade your fire. Meanwhile, your tailing position allows you to keep a keen eye on your target.

# KNOWING YOUR GUNS

Prior to WW II, fighter armament was still in its infancy. Mere decades earlier, pilots had dropped bricks, fired shotguns and shoved bombs overboard; even the machine guns they carried were small caliber and had low rates of fire. By the time of the Second World War, however, all combat aircraft were equipped with potent guns of some sort. Guns were either fixed (hard-mounted with a fixed aim point) or flexible (mounted on a rotating turret). While fixed guns were well-suited to small, maneuverable aircraft, flexible guns required a full-time gunner and were used mostly on the heavy bombers.

As maximum aircraft speeds increased and manufacturing materials became stronger, designers realized that more destructive gun power was needed to overcome heavier armor and ever-shrinking windows of shot opportunities. Research centered around creating better, faster and more powerful guns, and WW II became the golden age of gun combat.

## GUN LIMITATIONS

WW II warplanes normally had from two to six to eight guns that fired either bullets or cannon rounds. (The distinction between the two is fine, but important: cannon rounds deliver an explosive charge upon impact, bullets don't.) Cannon rounds obviously pack more punch and cause greater damage; however, cannons have a lower rate of fire, so the chances of getting a round on the target are lower than when you're firing a machine gun.

Perhaps more than any other factor, the weight of the round type affected overall gun performance. High projectile weights ensured a more devastating hit, but a lower rate of fire. Lightweight projectiles delivered less damage, but had a faster rate of fire, increasing the chance for multiple hits. During WW II, American fighters favored a high rate of fire, while their German equivalents were designed mainly for projectile potency.

A second factor affecting gun performance was the physical location of the gun. Some aircraft used nose-mounted guns that fired synchronized rounds intermittently through the nose propeller blades. Nose-mounted guns favored the enemy's odds of avoiding a hit. Because of the built-in delay between rounds in a nose-mounted gun, aircraft could often fly through a path of bullets without being stricken. Even if they were hit, WW II warbirds had relatively few systems that were susceptible to bullet damage. The fuel tanks, an engine, and the pilot himself were the most vulnerable components, while the exterior sheet metal could take damage from many rounds.

WWII aircraft had guns mounted on, in or under the wing, or somewhere on the fuselage. Wing-mounted guns fired at a slight angle toward the nose of the aircraft, and the two streams of bullets from each wing converged at some defined point in front of the aircraft. The alignment of such guns was accomplished either through *point harmonization*, in which the convergence point was optimally 700 to 800 feet, or by *pattern harmonization*, in which each gun was adjusted slightly off the point of convergence to cover a greater area of effect. In either case, the pilot had to know where this point was, and how to judge how far away his enemy was. Striking the enemy exactly at this point of convergence gave pilots the greatest lethal firepower.

The accuracy of warplane guns, however, left much to be desired. Mounted guns caused recoil problems, distributed bullets unevenly and altered the aircraft's center of gravity. Firing at a moving aircraft presented its own problems—the pilot had to estimate where to aim in order to score a hit. Eventually, lead-computing gunsights helped alleviate the latter problem, but didn't see use until the middle of World War II. These semi-automatic sights, with the help of a few manual pilot adjustments to measure a target's wingspan, could calculate range to the target and figure the necessary firing angle. It then displayed a floating "pipper" on a transparent piece of glass to assist the pilot in aiming.

## GUN TYPES

### MG 131 Gun—GER

Despite the fact that cannons were commonly used on aircraft, the Rheinmetall MG 131 12.7 mm machine gun was produced through 1942 and was the standard gun for many German aircraft during the war. It was a lightweight weapon that used an electrically driven firing mechanism, a feature that would later be adopted by most large-caliber aircraft guns.

Five different belt-fed types of ammunition could be loaded in this versatile gun. It fired linked rounds at a speed of 15 rounds per second. The Rheinmetall MG 131 was relatively slow as compared to faster American machine guns with a muzzle velocity around 760 m/sec (2,493 ft/sec), but had a faster velocity than the MK 108 cannon.

**MK 108 Cannon—GER**

A 30mm cannon, the MK 108 was used in no fewer than four of Germany's top-line fighters. It was originally designed to boost the firepower of existing aircraft and was hurried into service. Due to a lack of proper testing, the gun tended to jam frequently. When in operation, however, pilots held it in high esteem—it was rumored to split an aircraft in half at close range with as few as two hits.

Although the MK 108's rate of fire was slow (only about 10 rounds per second), the gun itself was lightweight, and several could be mounted on the same aircraft. It used pneumatic force to fire large, explosive rounds at a muzzle velocity just over 505 m/sec (1,657 ft/sec), slower than that of the MG 131 machine gun.

**MG 151/20 Cannon—GER**

This Mauser gun ousted the MG FF series previously used in the Luftwaffe and was adopted as the standard 20mm cannon.

Its 20mm caliber cannon rounds were heavy, but used less propellant than their 15mm predecessors. The gun made an excellent air-to-air weapon and could fire either 115g or 92g projectiles at a rate of about 13 rounds per second. Although it was slower than traditional machine guns and lacked the punch of the MK 108 cannon, the rounds had a faster speed (near 720 m/s, or 2,362 ft/s) and it was quite reliable and effective against fighters and lumbering bombers alike. It was perhaps the most important German gun of the war and saw action until 1944 in most combat aircraft, notably the Bf 109 and Fw 190.

**Hispano 20mm Cannon**

Originating from Hispano-Suiza, this well-known WWII cannon compiled all the best traits of other guns in existence at the time. The exception was the firing mechanism, which consisted of a gas piston, two metal plates and a breechblock that worked together to fire each round. Later versions, such as the Mk V Hispano, incorporated belt-fed ammunition. The resulting gun was dependable, and the fastest variant had a firing rate just over 10 rounds/second. Although the rate of fire was slow compared to machine gun, these cannon had much more powerful rounds. The Hispano 20mm cannon was developed under license during WWII as the American M1 and M2 cannon.

**.30 cal Machine Gun**

The .30 caliber machine gun was the lightest of the two most popular Colt Browning machine guns in service during WWII. The basic construction was traditionally in line with other Browning guns, with a recoil providing the force to move the barrel and breechblock. Early versions of this gun used fabric-linked ammunition belts, which were later replaced with

metal-linked belts. Ammunition for most Browning guns also eventually incorporated tracer ammunition (flare-type rounds interspersed into normal rounds) to help pilots gain an accurate idea of they were aiming.

This sturdy .30-caliber Colt Browning machine gun was used as early as WWI and saw service early during WW II. It was versatile and could be adapted to use as a fixed, synchronized, turreted or hand-aimed gun. The .30 machine gun was capable of firing 20 rounds per second and good at a range of nearly 2000 feet (609 m). Because aircraft became more resistant to gunfire, it was slowly demoted to a rear-firing tailgun as the .50-caliber version came about.

**.50 cal Machine Gun**

A larger version of the .30 caliber machine gun, the Colt-Browning .50-caliber weapon displaced the .30 caliber gun and became the standard forward-firing gun on US fighters. It was also an integral part of most bombers’ defensive armament (such as the B-24 Liberator). Part of the reason for this gun’s success was that it was easy to manufacture and it had good ballistic qualities.

The .50 caliber gun was typically mounted in the wings, where plenty of room was available for mounting and no synchronization was necessary (synchronized firing tended to lower a gun’s rate of fire). Although slower than the .30 caliber model, the gun’s extremely long range let attackers fire from a great distance and, according to some pilots, this weapon was more accurate than the 20mm cannon. It released approximately 13 rounds per second (upped to 20 per second post-WWII) and had a muzzle velocity of 887 m/s (2,910 ft/s) that rivaled that of the German MG 131 machine gun.

**GUN SPECIFICATIONS**

The following table lists information about the machine guns available on each aircraft in the game. Each gun type has its advantages and disadvantages.

<b>Guns (# x Type)</b>	The number and type of guns carried by that aircraft. For instance, “6 x .50 cal” means that the aircraft carried six separate .50-caliber guns.
<b>Rounds</b>	The number of bullets or cannon rounds carried for a single gun of that type.
<b>Location</b>	The physical positioning of the gun on the aircraft.
<b>Muzzle Velocity</b>	The speed of the round (in meters/second and feet/second) the bullet or cannon round as it leaves the muzzle.
<b>Rate of Fire</b>	The number of rounds per minute fired by the weapon.

## GUN SPECIFICATIONS

Aircraft	Guns (# x Type)	Rounds	Location	Muzzle Velocity (m/sec, ft/sec)	Rate of Fire
<b>ALLIED</b>					
P-38J	4 x .50 cal	500	fuselage	887m/s / 2,910 ft/s	800 rds/m
	1 x 20mm	150	fuselage	880m/s / 2,890 ft/s	600 rds/m
P-47D	8 x .50 cal	200	wing	887 m/s / 2,910 ft/s	800 rds/m
P-51D	6 x .50 cal	500*	wing	887 m/s / 2,910 ft/s	800 rds/m
Spitfire Mk IX	4 x .303 in	350	wing	731 m/s / 2,398 ft/s	1,200 rds/m
	2 x 20mm	120	wing	844 m/s / 2,769 ft/s	600 rds/m
* for each inner wing gun					
<b>GERMAN</b>					
Bf 109G-6	1 x 30mm	60	airscrew	505 m/s / 1,657 ft/s	600 rds/m
	2 x 12.7mm	300	cowling	760 m/s / 2,493 ft/s	1,000 rds/m
	2 x 20mm	120	wing (pod)	720 m/s / 2,362 ft/s	700 rds/m
Fw 190A-8	4 x 20mm	200	wing (root)	720 m/s / 2,362 ft/s	700 rds/m
	2 x 12.7mm	475	cowling	760 m/s / 2,493 ft/s	1,000 rds/m
	2 x 30mm	55	wing (pod)	505 m/s / 1,657 ft/s	600 rds/m
Me 262A	2 x 30mm	80	fuselage (top)	505 m/s / 1,657 ft/s	600 rds/m
	2 x 30mm	100	fuselage	505 m/s / 1,657 ft/s	600 rds/m

## TAKING THE SHOT

Once you've moved into an advantageous position, the next logical step is to set up for a shot at your opponent. You'll need to take many things into consideration: your flight path and airspeed relative to your opponent's, the separation distance, the angle of approach, etc. Apart from all this, consider that the bullet itself is subjected to many factors after being fired. You're firing while moving, and trying to hit a moving target with a bullet that's following a curved path. Add to that wind resistance, gravity and acceleration, and queuing up a successful gun shot becomes an even more complicated issue.

The following diagram illustrates, from the cockpit viewpoint, the best angles for each type of shot. The remainder of this section covers the specific tactics and considerations associated with gun-based combat. By keeping several factors in mind, you can increase your chances of a successful shot.

### Gunsight

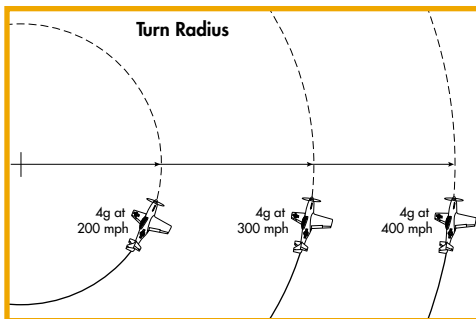
The earliest gunsights (present in WWI) were fixed "ring and bead" sights, which consisted of a simple ring with horizontal and vertical cross braces mounted on the cockpit dash. A vertical rod with a small bead at the top was set back several inches.

The pilot moved his head until he lined up the offset bead with the center of the ring, aimed the gun accordingly by pointing the aircraft in that direction, then fired. The size of the target as compared to the ring gave pilots an instant approximation of how far away the enemy was. If the wings of the target spanned half the distance of the ring, for instance, the pilot was operating at close to his maximum gun range. The biggest drawback to the ring and bead sight was that if the pilot's head were not positioned correctly, large margins of error were introduced.

Prior to WW II, most ring and bead sights had been replaced by a more accurate telescopic sight that required the pilot to place his eye on the scope in order to aim correctly. Combining glasses (concentric reflector sights mounted on the cockpit dash) were common by the time the war began. These sights were made of transparent glass upon which an illuminated circle was projected. As long as the pilot could see the circle, his head was in the correct position for aiming. The center of the sight was called the piper. Many sights also incorporated settings that increased the piper width to match the wingspans of different target aircraft. Later in the war, gyroscopic lead-computing optical sights (LCOS) were invented. These systems were capable of automatically computing the lead angle and altering the piper position on the sight accordingly.

### Target Speed

Another important factor to take into account is your opponent's current airspeed, or target speed. Unfortunately, there's no easy way to determine this given the equipment available in WW II aircraft. You'll have to rely on your vision and good judgement.



Here's an important note—at higher airspeeds, turns are looser (the radius of a turn increases). At slower speeds, turns are tighter (the radius of the turn decreases). If you're traveling at high speed in an aircraft with a large turn radius and low turn rate, it's significantly more difficult to alter TAA (target aspect angle—see below). At slower speeds, or in an aircraft with a small turn radius, you can alter the aspect angle much more easily.

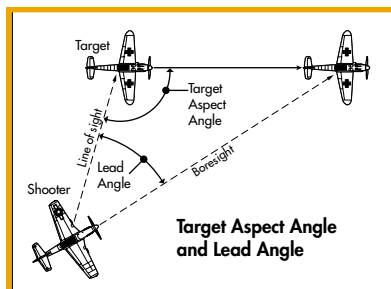
### Target Aspect Angle

More important than your target's speed is the target aspect angle (TAA), or the angle of the target's flight path relative to your line of sight (LOS). Why is this important? TAA affects several aspects of combat. First, your guns have a certain cone of effect, and you must maneuver so that your current aspect angle overlaps with the gun's effective area. To get an

effective hit, you're going to want to minimize this angle at all times. If you're defending against an attack, the objective is to increase this angle (and thus decrease your chance of getting shot).

Aspect angle can range from 0 to 180°. If you're tailing an opponent (the most desirable angle), you have an aspect angle of 0°. If you're flying head-on or directly away from each other, you have an aspect angle of 180°. Approaching from any other direction, your aspect angle falls between these two values.

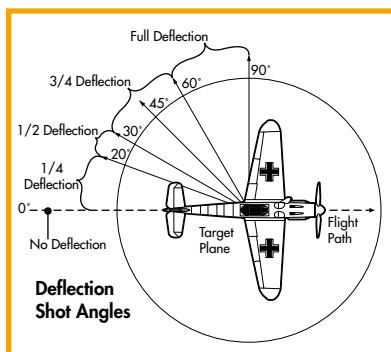
Keep in mind that airspeed and inertia affect how quickly you can change the target aspect angle.



### Deflection Shooting

Deflection shooting refers to anticipating your target's movement and firing your shots slightly ahead of his flight path. The objective is to "lead" the target into your stream of bullets without wasting your entire store of ammo.

The angle between the center of your boresight and the point at which you're aiming is called the *deflection angle*. Shots taken at that angle are called *deflection shots*.



To estimate this angle, you must consider the aspect angle, your target's speed, and his range. A small lead angle shot is called a *low-deflection* shot. If the target is flying faster than you are, perpendicular to you, or making a breaking turn away from you, the lead angle will be larger. This is called a *high-deflection* shot. Finally, firing a shot straight into an opponent in front of you has no lead angle and is called a *zero deflection* shot.

### Snapshots

A *snapshot* is a quick burst of rounds, approximately the amount delivered by a single, half-second pull of the trigger. You'll be forced to take less-accurate snapshots when you have limited shot opportunities, and the deflection angle is very high (as a defensive move, you can force your attacker to take snapshots by turning *into* a side attack instead of away from it).

This type of shot is common in a quick, turning dogfight, when you may not have time or room to line up for an extended leading shot. If you ever hear a pilot refer to “raking” his opponent, he’s referring to taking snapshots.

Good timing is essential with a snapshot. You want to fire rounds so that they strike in the brief window of opportunity you possess as the target crosses your forward flight path.

### **Tracking Shots**

Tracking shots are much more accurate than snapshots, and are taken at low deflection angles between 0 and 30° off the tail. The goal of this shot is to keep the target centered in your sights for an extended period of time to verify aim and increase accuracy.

If an opportunity is afforded, always choose a tracking shot over a snapshot. This is not always possible under combat circumstances, since maneuvering into and maintaining a good tracking shot position can take considerable time and effort. It’s not a good idea to try this against bombers with rear gunners, or if the air is filled with bandits.

### **Gravity Effects on Projectiles**

Gravity has just as much of an effect on gun rounds as it does on your aircraft. Bullets will start out level, then make a slow, arc drop toward the ground. Unless you’re firing from point-blank range, you’ll always need to compensate for gravity by firing slightly above your opponent.

### **The Sure-Shot Technique**

The absolute best shot you can take is one on your opponent’s tail, at very close range. Once your opponent fills up your windscreen, many factors that could lessen your chances of a hit effectively disappear (leading angle, range, gravity, and target speed).

Whatever firing method you choose, you must ultimately have patience. Don’t fire prematurely or in desperation. Instead, wait until you’re within weapons range and in position for a good shot. Remember, ammunition is precious. You only have a finite number of rounds with which to accomplish your mission.

## **COMBAT MANEUVERS**

After the element of surprise is gone, combat becomes a battle of wits and endurance. Before you commit to a fight, consider your aircraft’s strengths and weaknesses as compared to your enemy’s aircraft.

With slower top speeds and short-range weapons, WW II aircraft were not capable of combat beyond visual range. However, close-in, guns-only combat is a unique scenario that pushes a pilot’s skills to the limit.

## ENERGY

You should have a practical understanding of energy to know when to use different maneuvers. In terms of aircraft, energy is the amount of current or stored directional force your plane has available. It is commonly used as a combat term, referring to how much mechanical energy your aircraft has versus your opponent's aircraft. In the air, energy relates directly to maneuverability.

Energy is classified into two types. Energy that is currently in use is called *kinetic energy*, and is determined by the aircraft's mass and current speed. If you climb, you're consuming more kinetic energy. *Potential energy* is stored energy in the form of altitude. If you dive, you convert altitude (potential energy) into speed (usable energy).

## Choosing Your Fight

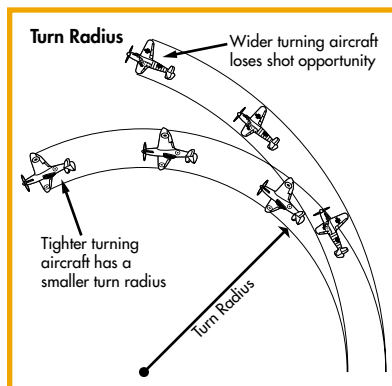
The terms "energy fight" and "turning fight" convey two different approaches to combat based on who has more speed and/or the faster airplane. In an energy fight, an aircraft climbs, accelerates and lays heavy on the throttle as the pilot struggles to outmaneuver his opponent by using his speed advantage. He makes a series of slashing attacks, sharp hit-and-run attacks punctuated by dives, climbs and speedy breakaways.

In a turning fight, an aircraft with superior turning abilities tries to outfly the other pilot using short, quick turns. This is the traditional aerial dog-fighting battle depicted in most old WW II movies—two opposing pilots zoom through the skies, wrestling to acquire a positional advantage. Each turn draws away precious airspeed, and eventually, one pilot must conquer or disengage.

Before going into battle, it's important to decide what kind of fight you want to pursue. Either kind of fight can work in the right situation, but not unless it takes advantage of the dominant flight characteristics of your fighter.

## TURN RATE/RADIUS

All aircraft have two basic turn-related performance characteristics, known as *turn rate* and *turn radius*. The first describes how fast the aircraft can turn in degrees per second, and the second indicates the size of the turn arc. In general terms, faster airspeeds translate into faster turn rates, but create large, relaxed turn radii. The converse is true as well: slower airspeeds give slower turn rates but tighter turn radii.



### Defeating a Better Turn Radius

If you're chasing an aircraft with a tighter turn radius and your aircraft has a quick roll rate, rolling away during a turn can help you increase closure. As the aircraft you're tailing starts his tight turn, roll away from the direction of the turn and then throw the stick forward (in a normal turn, you pull back on the stick without rolling). The end result is that you swing under or over your opponent and push the nose toward the completion point of his turn.

### DEFENSIVE MEASURES AGAINST GUNS

In close-in combat, the goal of the fight is to see who can maneuver into the best gun position and achieve a gun solution. If you're on the attacking end of the fight, the job is much easier. From the defensive perspective, however, your task is to shake off what could very well be a fatal attack.

Any time you're staving off a gun attack, your immediate reaction should be to assess your aircraft's performance against that of your enemy. The second reaction should be to apply any advantageous maneuvers you can perform with your aircraft.

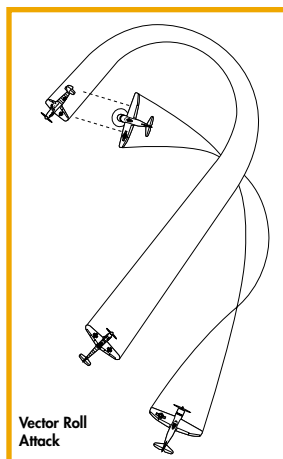
### EXTENDING

- ★ Use to gain separation from an attacker
- ★ Use only if your aircraft has a speed or climb/dive rate advantage

*Extending* is basically an all-out run to put distance between you and your attacker. It is only useful, however, if your aircraft has a faster maximum speed or dive/climb rate. This method is often referred to as gaining *separation*. To achieve separation and extend the distance between you and your attacker, avoid turning if at all possible. Each time you turn, you provide your opponent with the opportunity to shave off distance.

The premise is simple: if you can fly faster than your opponent, fly level toward safety. If you can climb faster, climb to put distance between you and your attacker. If you have altitude and think you can out-dive him, drop the nose.

Don't try an extension maneuver against an aircraft with comparable flight performance characteristics unless you have a safe lead (beyond gun range) and enough fuel to make it into safe territory.



## DEFENSIVE BREAK

- ★ Use to shake off a tailing enemy
- ★ Follow up with a reverse break turn in the opposite direction

A break turn can be either an offensive or defensive maneuver, depending upon the situation, but becomes especially useful when someone's on your six. It involves making a hard, banking turn to bring about a quick change in direction.

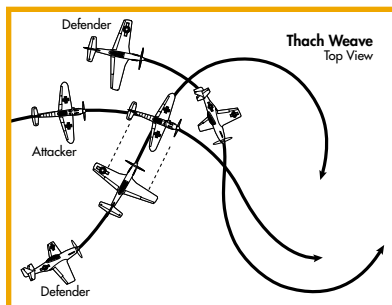
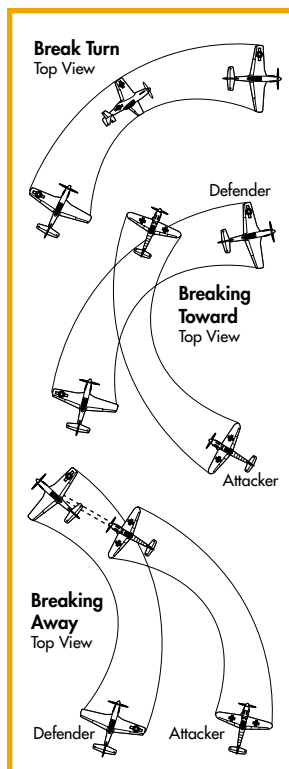
If a tailing enemy is approaching you from a side angle, follow the often preached and more often practiced tenet of battle: "turn toward your attacker." The goal is to turn toward the attacker (e.g., if he's off your left side, turn left) in order to increase the deflection angle as much as possible. Although it makes instinctual sense to want to make a break turn away from the attack, that actually keeps you in the enemy's line of fire for a longer period of time. If you turn toward your attacker, you're affording him only a snapshot opportunity. You'll pass him by and make it harder for him to maneuver back onto your tail.

To conduct a break turn, apply strong left or right stick to go into a hard roll. Simultaneously, pull the stick back to pitch up the nose to initiate a sharp turn.

If you really want to shake him off, try making a break turn and then follow it up with a break turn in the reverse direction. Keep in mind, however, that each turn bleeds off some of your airspeed. If your opponent appears to be matching you turn for turn, you can easily find yourself in a scissors situation. At that point, it's a slugging match to see who can sustain enough speed to remain scissoring longer than the other. Eventually, one fighter is forced to break off the attack.

## THACH WEAVE

The Thach Weave, contrived by veteran WW II pilot Jimmy Thach, allowed two aircraft to cooperate using a break turn in a 2 vs. 1 situation in which the enemy is tailing two friendlies. In this maneuver, the friendly pilots break away from one

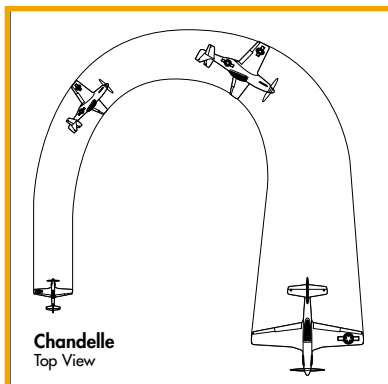


another. Logically, the enemy will choose to follow one of them. The pursued friendly aircraft then immediately breaks inward to lead the opponent into the other friendly aircraft's path of bullets.

### CHANDELLE

- ★ Use to gain altitude and reverse direction
- ★ Use when you can afford to make a wide-radius reversing turn
- ★ Use to engage an enemy attacking from your rear

A chandelle is a wide, 180° sweeping turn and is one of the less extreme combat maneuvers you can make. It's not a strategy you want to take in close quarters, but it's a good preparatory move if you've spotted an enemy behind you and want to turn to face him.

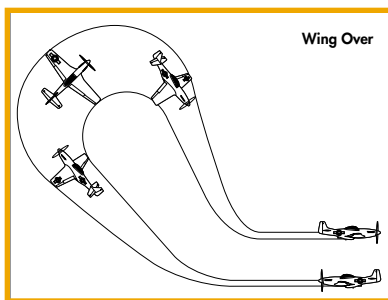


To make a chandelle turn, start out in level flight. Gear up the throttle, then commence a gentle quarter-roll in one direction and apply soft pitch. Don't use too much pitch, or you give up too much airspeed and cause a stall. If you maintain these control settings, you eventually reverse direction, at which point you can level out or dive down on the attacker below.

### WING OVER

- ★ Use to reverse direction without changing altitude
- ★ Use to initiate multiple dive attacks on slow targets

The wing over is a risky maneuver you can use to reverse direction and return to your pre-turn altitude and heading. As with the chandelle, you turn around, but this time you're using pitch and rudder. You'll find this maneuver conducive to multiple diving attacks on slow-moving targets that can't easily alter their flight paths (such as bombers).



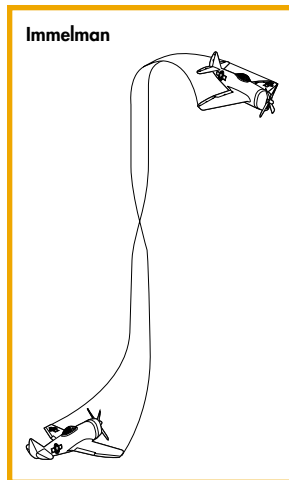
To carry out a wing over, apply pitch and throttle. Go into a steep climb (much steeper than a chandelle climb). Once you feel the aircraft begin to stall, sharply kick the rudder either left or right. This causes the nose to yaw through 180 degrees, essentially swinging it up and over the topmost

point of your turn and then dropping it toward the ground. Imagine that the aircraft is on a ramp — as you approach the top, the nose is pointing nearly vertical. As you slow down, you pivot the nose sideways so that it points down, and then the aircraft “rolls” down the ramp.

## IMMELMANN

- ★ Use to quickly gain altitude and reverse direction
- ★ Use when you want to make a tight-radius reversing turn
- ★ Use to engage high-flying enemies going in the opposite direction

An Immelmann was a popular maneuver perfected by German pilots, but adopted by many who realized its success. It reverses your direction and puts you at a higher altitude, but reduces your overall airspeed. Use this maneuver when an enemy aircraft passes overhead and you want to engage him, or you suspect that he’s going to engage you.



Before making an Immelmann turn, raise your airspeed—the first part of the maneuver is an extreme vertical pitch-up that uses a lot of your aircraft’s energy. Apply heavy back pressure on the stick and hold it until you’ve completed a half-loop. As you come into level, inverted flight, release the back pressure and instead push the stick left or right to make a half-roll. If you perform this move correctly, you’ll be reversed and flying at a higher altitude.

If you have a lot of airspeed up front, you can experiment with the Immelmann by making a banked turn as you start to come out of the half-loop. This allows you to come out of the loop with a slightly different heading. Or, you can apply enough extra pitch to extend the loop into a dive. Either variation can be useful if the enemy you’re pursuing makes an early break to one side or goes low.

## SPLIT-S

- ★ Use to quickly lose altitude and reverse direction
- ★ Use when you want to make a tight-radius reversing turn
- ★ Use to engage low-flying enemies traveling in the opposite direction
- ★ Use to disengage from a battle

This maneuver is popular among all pilots and holds no cultural barriers—British pilots call it a half-roll, Americans call it the split-S, and the Germans refer to it as the Abschwung. Almost an exact reversal of the Immelmann, a split-S maneuver changes your direction and places you at a lower altitude. And since you're essentially making a dive, you'll gain some airspeed coming out of the turn. You can apply the split-S to many situations: to drop altitude and change direction, to engage a low enemy or to duck out of battle entirely.

Start a split-S turn from a level altitude of several thousand feet or more. The first step is to invert the aircraft by pushing the stick left or right and making a half-roll. Once you're upside down, pull the stick back into your lap and dive into a half-loop. After you have the horizon in your sights, level out. Good judgment is of the essence here if you're using this maneuver as an attack procedure: you must be able to estimate where to begin the turn. If you don't have enough separation between you and the enemy aircraft, you may approach him too quickly and overshoot or pass him by.

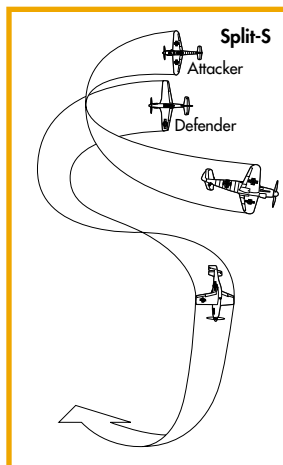
You should avoid using this against opponents with superior diving abilities. And as an added cautionary note, make sure there's room for error between you and the ground when you make a split-S turn. In some cases, your increased airspeed can cause the control surfaces to freeze up. If that happens, you'll have to let the aircraft fall and try opening your dive brakes or flaps to slow down.

### SKID

- ★ Use to force an aircraft to pass you
- ★ Use to throw off a tailing attacker's gun bead
- ★ Use to lose altitude without affecting airspeed or heading

A skid is nothing more than laterally "braking" in mid-air by using your rudders and ailerons. This maneuver is aptly named, as it causes the aircraft to skid sideways. You can use it to shake off gunfire and disrupt your attacker's aim on you.

To perform a skid, push the stick gently left or right to drop one wing, and then turn the rudder in the opposite direction (if you move the stick right, use left rudder, and vice-versa). You'll start bleeding off some altitude, and the aircraft will slide in the direction of the lower wing. Sometimes, your enemy will mistake this maneuver for a turn and will attempt to follow it.



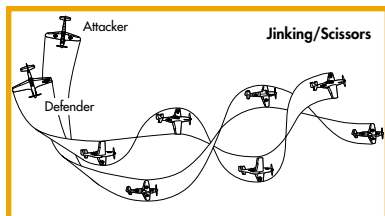
## UPSETTING THE ATTACKER'S AIM

If all else fails and you find yourself in someone's sights as they tail you, you want to minimize their shot opportunity in every way possible. The best way to do this is to create as much of a deflection angle as you can under the circumstances. The greater the angle between your attacker's guns and your flight path, the larger the margin for error.

### Jinking

- ★ Use when you're being tailed inside or close to gun range
- ★ Use to force a faster-flying attacker into passing you

*Jinking*, sometimes called *scissoring*, is a series of quick, alternating break turns. You push the stick left, then right, then left, then right again... and so on. You can make loose turns, or tighten up the turn radius with the aid of your rudders. The goal is to avoid approaching gun or cannon rounds and disrupt your attacker's bead on you.



Jinking is especially beneficial if you know that your opponent has a faster airspeed. He's trying to cut distance, so his airspeed is higher and he'll have a hard time holding his nose far enough into the turn. The most likely outcome is that he'll pass you and overshoot.

With each successive turn, you force him to cut the distance separating you. This goes back to concept that "the shortest distance between two points is a straight line." In this case, the line is a slight curve, and the aircraft are points, but the same principle applies. To follow your turn and maintain you in his sights, he must cut your turn short.

### Violent Maneuvering

The key to successfully avoiding a tailing attack is to be as unpredictable as possible. The more you thrash your aircraft around, the harder it is for your opponent to train his weapons on you. Try combining maneuvers—for example, a loop interrupted by a break turn, or a quick break turn after any maneuver.

Make sure that whatever you do, you have enough altitude to do it in, and that you aren't flying into worse trouble. There's nothing more disheartening than successfully shaking an attacker with a series of jinks followed up with a split-S, only to find yourself staring down the sights of an approaching enemy wing.

Perhaps one of the best-known violent maneuvers belonged to Luftwaffe pilot Erich Hartmann. A believer in the hit-and-run slash attack, he avoided dogfighting if at all possible. In the few times that he did find an

enemy chasing him with a stern attack from behind, he would wait coolly and wait for his opponent to commit to an attack. When that happened, Hartmann would throw his stick forward full force and drop down into an uninverted, negative-G loop. This drew him below the attacker's line of sight and placed him in a near-weightless state. Most pilots were completely taken aback by this bold maneuver and failed to follow.

An American pilot by the name "Killer" Caldwell took Hartman's concept one step further, adding rudder to kick his aircraft to one side and throttle to speed up the uninverted loop. This last move coined the phrase "stuffing it all into the corner."

Peter Brothers used a highly unconventional and subtle method to fool his would-be attackers. He purposefully trimmed his aircraft so that it flew with constant sideslip, figuring that opponents would misjudge his direction of flight. Brothers felt that his slightly lilted aircraft gave him a better view to a subtle advantage in battle. The trick succeeded in its own right, evident in his 16 victories in battle.

## BOMBER ESCORT/INTERCEPTION TACTICS

Most bombers prior to 1930 were simple monoplanes and capable of carrying small bomb loads under a thousand pounds. But as engines and airframes grew more powerful and reliable, it became possible to build airplanes dedicated to hauling bombs over long distances. The resulting heavy bombers could carry thousands of pounds of bombs and enough fuel to travel deep behind enemy lines.

The concept of long-range, level bombing introduced undreamt-of mass destruction and also brought about a new era of military planning and attack theory: the age of bomber escort and interception. Despite the addition of a number of machine guns, large, lumbering bombers made easy targets for a fighter squadron bent on breaking up the attack. Many fighters were tasked with doing just this, and a number of pilots spent a good portion of their time either protecting or attacking bombers en route to a target area.

Bomber escort and bomber interception missions became a vital part of war—after all, one of the deciding factors in the outcome of WW II was the near-obliteration of Germany's rail system by bomb attacks.

## ESCORT MISSIONS

Strategic bombing was an offensive action, but it called for defensive action as well in order to protect the bombers themselves. Initially, bombers flew in a mutually supportive boxed formation at staggered altitudes, using their mounted guns to protect one another. This failed to be very effective, however, as losses mounted to unacceptable levels. Escort fighters became

a vital necessity for the survival of a strike force. American bombers came to rely heavily on fighter escorts, which would accompany the bombers to (or at least near) the target area. Spitfires, P-47Ds, P-38s and ultimately the more maneuverable and longer-ranged P-51Ds were used as escort craft. Range was the most critical problem for these escort flights, since the smaller fighters weren't equipped with adequate fuel supplies to complete the entire journey. Fuel tanks mounted on the underbelly later alleviated this problem to some extent.

There were tactical issues to resolve as well. Escort aircraft were assigned to stay with the bomber group, but had much faster cruising speeds. This meant that they often had to fly left-right weave patterns to avoid flying too far ahead the bombers. If the squadron was bounced by enemy aircraft, the escort pilots had to leave their bombers unattended to fend off a particular attacker, and then rush back to the formation to resume their protective duties. As Allied air forces grew in size, strategists began assigning free-ranging aircraft to the flight in addition to the escorts. These pilots had full freedom to roam in front of or to the side of the formation, and they would often sweep a 100-mile radius around the formation.

## **INTERCEPTION MISSIONS**

Once fighters were tasked with interception missions against bombers, traditional dogfighting maneuvers failed to apply. Bombers presented a more dangerous challenge. The combined firepower of bomber formations accounted for many downed fighters that dared to approach too closely, and pilots learned to make their attacks from above or from the side. Each new enemy bomber that entered the battle arena fell under scrutiny by enemy pilots, who sought to find its Achilles' heel. Bombing strategies were examined as well, and it was there that Germany first exploited a hole in the US bombing strategy.

Most of the time, escort aircraft flew several hundred feet astern or above the bomber. Sometimes, if free-ranging fighters were assigned to the flight, a few fighters would break off and scout out the area ahead of the bomber for Luftwaffe aircraft. The idea behind doing this was to split up any approaching squadrons before they approached the bombers. The Germans, however, soon realized this intent and reversed its advantage—aircraft would intentionally meet the free-ranging American pilots, who would promptly discard their drop fuel tanks to engage in combat. After the escort craft consumed their fuel and were forced to turn back, the Germans would strike the bombers.

### BOMBER ATTACK COUNTERMEASURES

As with all countermeasures, there soon came a counter-countermeasure to Germany's new attack tactic. American strategists started sending out multiple squadrons—one to scout ahead and engage the initial wave of fighters, and a second to remain tied to the bomber formation. German fighters were then forced to fly at high speeds and try to break through the ranging fighters to make their attacks.

When they did attack, Germans tended to take on US bombers (especially the B-17) from the front, with the entire flight approaching in a high-closure V-formation. The point of the "V" varied—sometimes leading the formation, and sometimes trailing it. U.S. gunners found this tactic disconcerting and had difficulty determining the flight's actual range. To counter this, large formations began tightening up horizontal and vertical spacing to present a smaller target for the approaching fighters. Most often, six bombers would travel together at only 150 feet (45 meters) of vertical separation and total horizontal spacing of less than 800 feet (244 meters).

As German pilots continued to attack bombers from the front, bombers were equipped with more forward-firing guns. A new variety of attacks were created, one of which was to fly at the bomber from below and behind. Once again, the gun mountings were adjusted to compensate for this, and rear, low-firing guns were adopted. Then, as fighters grew more powerful, dive-bomb attacks from above and the front became prevalent. The dive would originate about 5500 feet (1676 meters) above the bomber, where the only protection was a top fuselage turret gunner. If you examine the armament changes on bombers during WW II, you'll see that defensive front and rear gun positions were sparse at first, but eventually migrated to cover other vulnerable areas of attack.

### ATTACKING BOMBERS IN THE GAME

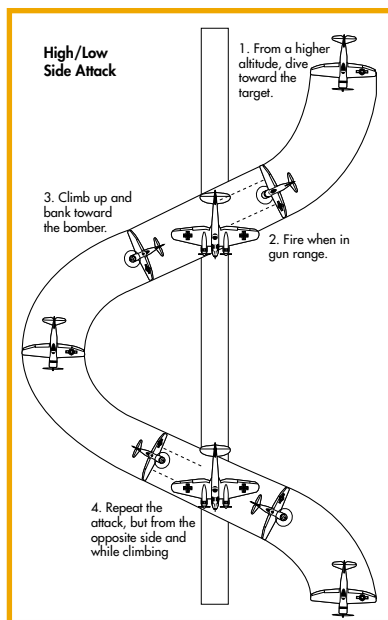
In the game, attacking a bomber is one of the more difficult missions you'll face. Although the bombers themselves present large, barely maneuverable targets, many are equipped with tail, top or belly gunners, and escort aircraft are bound to be present. Before you can make a successful attack on a bomber, you must overcome both obstacles.

The rest of this section covers the basic maneuvers you can use to take down bombers. In general, you want to make your attack either high or low and off to one side to avoid gunner fire. If you're tasked with attacking a specific type of bomber, it's always a good idea to study up on your opponent's armament ahead of time.

## High/Low Side Attack

Most bombers have rear tailguns; therefore, you aren't going to want to close in on them from behind. A high and/or low side attack allows you to stay out the gunner's sights for the most part and affords you a series of shots at the rear left and right quadrants of the bomber. You need to be an accomplished deflection shooter for this maneuver—each time you take a shot, you'll be approximately 35 to 45° off the rear of the bomber.

To make a *high side pass*, position your aircraft about 1500 feet (457 meters) above and ever-so-slightly ahead of the intended bomber target. Laterally, you should have several wingspans worth of separation between you. Start a steep dive and bank toward the rear of the aircraft at approximately 45 lateral degrees. As you move within gun range, open fire with leading shots. Let loose a good volley, and then break off the attack as you dive underneath the bomber.



Once you've cleared the aircraft, pull up out of the dive and give yourself some lateral space. This time, you'll make a low pass. Pitch the nose up and bank back toward the bomber, reversing the strike and attacking the opposite rear quadrant. Fire off another long burst of shots, then pull up and over the bomber. Keep climbing, and repeat another high side attack.

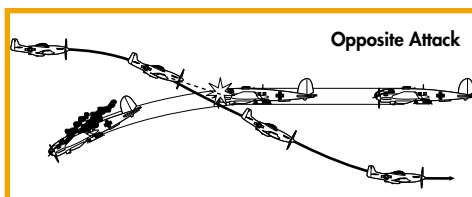
This maneuver resembles a weave pattern, except that you're switching between high and low attacks. You're essentially flying an alternating high and low ribbon pattern around the bomber. The longer you can hold the bomber in your sights before diving or climbing, the more you'll have banked, and the smaller the angle of deflection.

If you don't have sufficient time to achieve a 1500-foot (457-meter) altitude advantage but you're approximately 500 feet above the enemy, you can implement a low side pass. This involves essentially the same methodology, except that your initial dive is shallower, and you won't have much power when you reach the climbing portion of the maneuver. A low pass is good if you think you can take out an already-damaged bomber, or you're only interested in taking a single swipe at it.

- ★ Fly about 1500 feet (457 meters) above, to the side and just ahead of the bomber
- ★ Pitch down and bank toward the rear quadrant of the bomber
- ★ As you move into gun range, shoot
- ★ Break off the attack and dive below the bomber
- ★ After you emerge from below the bomber, pull out of the dive
- ★ Use your acquired dive speed to climb, banking away from the bomber
- ★ Bank inward and up toward the bomber's other rear quadrant
- ★ Repeat the attack, this time climbing instead of diving

### Opposite Attack

Hectic combat situations won't always give you time to position yourself correctly for a tracking shot. Opposite attacks are a practical solution in these cases, as they allow you to take passing snapshots without worrying about lead angles.



You can make an opposite attack while flying higher, lower or head-on against an opponent. If you're attacking high, you need at 2000 feet (610 meters) above and below your intended target—the maneuver requires space both for the dive and the recovery. Pitch down make a gentle (but expedient) dive in front and under your victim. In the brief moment that you have him centered in your sights, let loose a spray of bullets. A low attack is similar, except that you're climbing up and in front of the enemy.

The most dangerous option is a level, head-on attack. Although it doesn't involve diving or climbing, it places you directly in front of the bomber for an extended period of time.

- ★ Fly above, below, or level with the bomber as you approach it
- ★ (High attack only) make sure you have ample room for dive recovery
- ★ As you move within gun range, make your diving (or climbing) approach
- ★ Fire as the target crosses through the center of your sight
- ★ Dive below (or climb above) the target before you reach it

## Overhead Pass

Some defensive maneuvers can be converted into offensive attacks against bombers. A variation on the split-S is useful if the bomber is flying toward you, and you can use back-to-back split-S and Immelmann turns to make attacks on a bomber flying the same direction.

For an overhead pass on bomber with a similar flight path to yours, maneuver so that you're flying ahead, above and well off to one side of your opponent. Start a wide, banking descent toward the bomber, applying some rudder in the process to assist the turn. After you complete the 180°, banking turn, make a half-roll to invert your aircraft. Then, yank back on the stick to pull a half-loop. Toward the end of the loop, take your shots at the bomber. You'll then need to immediately bank left or right to break out of the tailgunner's firing range.

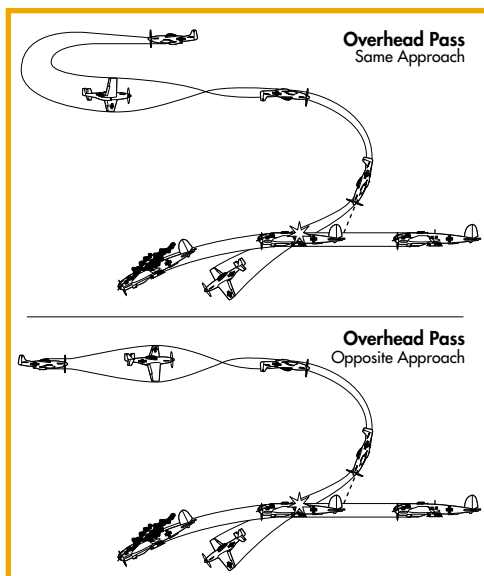
You can make a head-on version of this attack against an approaching bomber. Fly slightly above your opponent as you close. Once you pass overhead, invert the aircraft and pull back on the stick to fly a half-loop. As you come out of the loop, start firing. Make sure you bank hard in one direction to set up for another attack approach.

- ★ Fly ahead, above and to one side of the target
- ★ Make a wide, banking descent toward the bomber
- ★ Continue the descending turn for 180 degrees
- ★ Roll to invert your aircraft
- ★ Pull back on the stick to perform a half-loop
- ★ Shoot as the bomber crosses your sight
- ★ Bank left or right to avoid tailgun fire

---

**Note:** For a pass against a bomber flying the same direction, skip the first three steps.

---



### AIR-TO-GROUND COMBAT

The history of air-to-ground attacks dates back to pre-WWI, when methods of striking from the air were first conceived and tested. Prior to this, battles occurred on the ground, and troops fought against one another. The first documented bomb attack occurred in 1911, when a young Italian lieutenant named Giulio Gavotti tossed several small objects over Turkish troops. The earliest “bombs” ranged from large rocks to flechettes to grenades that pilots dropped by hand over the edge of an aircraft’s cockpit. Soon, pilots were stringing small 2kg bombs over the edge of the aircraft and pulling pins with their teeth before dropping them on the enemy.

On a large-scale basis, the Germans were the first to use bombing as a true convention of combat. Their infamous Zeppelin raids of WWI were but a foreshadowing of what would follow in the next few decades. These early strategic bombing attacks lacked accuracy, raising the controversial issue of area attacks near cities and other civilian population centers. These attacks were psychologically damaging for the victim side, whether the enemy was dropping bombs or leaflets designed to lower moral support.

It didn’t take long for military strategists to begin devising ways to defeat the enemy through bomb strikes aimed at strategic targets. By WW II, the terms “carpet-bombing,” “skip-bombing” and “dive-bombing” were commonplace vocabulary. Aircraft were built specifically to serve this purpose, and countermeasure aircraft and ground guns were built to oppose them.

### DIVE-BOMBING

Dive-bombing is a successive attack that consists of four distinct phases: a level approach, the dive itself, the weapon release, and the escape. You should ensure that you’ve got at least 10,000 feet (3048 meters) of altitude. The diving portion of the attack will consume a good chunk of your altitude, and you’ll need room to pull out of it.

Dive-bombing generally refers to all attacks between 70° (near vertical) and 90 ° (pure vertical). At smaller angles, it’s usually called skip-bombing. A vertical dive usually results in the best aim because you’re flying straight down at the target. However, the bomb must be released earlier in order to pull out of the dive in time.

#### To dive bomb:

1. **Approach.** Once you’ve spotted your ground target, line up with its longest side. This gives you more room for error, and you may score multiple hits.

2. **Dive.** Drop the nose down by pushing forward on the stick. Ideally, you want your dive angle to be between 60 and 70 degrees below the horizon, and you want the target to be just in front of you when you start the dive. Chop the throttle completely. Keep diving down toward the target and align your nose with the edge of the target closest to you.
3. **Release.** Somewhere between 2000 and 1500 feet of altitude (610 to 457 meters), release the weapons. You should be aiming near the front edge of the target—the bomb will always travel further forward due to momentum, so this increases your chance of one or more hits.
4. **Pull out.** Immediately apply heavy back pressure on the stick to level out, and then fly full throttle away. The best escape route is a low one—the lower your altitude, the harder it is for enemy ground guns to get a good shot off at you.

## SKIP-BOMBING

A *skip-bombing* attack (sometimes referred to as *glide-bombing*) is a gently diving bomb attack in which the pilot “lobs” the bomb at a target. It is normally made at altitudes below 5000 feet and at a dive angle less than 30°. This is perhaps the least accurate bombing method, short of closing your eyes as you approach the target area.

In a skip-bombing attack, you drop the nose down into a 30° dive. When you’re at an appropriate distance from the target (“appropriate” referring to your best guess), release the bomb and pull out. Alternatively, pull up and then release the bomb. This in effect tosses the bomb off the rail at a slightly upward trajectory and increases its forward distance.

In effect, a skip-bombing attack is similar to a forward throw in baseball—the projectile travels forward, then drops due to gravity. The inaccuracy of this type of attack derives from the difficulty of estimating the correct release point.

## ROCKETS

Rockets are large, unguided, rocket-powered warheads intended for ground targets or air targets. Early rocket research can be credited to the Soviet Union, which started developing rockets as far back as 1920. Rockets would remain subsonic (slower than the speed of sound) until midway through WWII and see extended use as an air-to-air and air-to-ground weapon. Not terribly expensive by military standards, they were highly effective and adopted by ground, naval and air forces alike throughout WW II.

By 1942, the 3-inch RP (rocket projectile) had been adapted to British aircraft and multiple rockets could be fired from rail launchers under the wings. The typical rocket in use had a 60-pound explosive charge warhead, while a smaller-pound version was used to “spear” U-boats.

US rockets copied British designs and came into use in 1943, when the USAAF adopted the M8 4.5-inch rockets for aircraft use. By mid-1944, the five-inch wide, 69-inch long rocket had become the American rocket of choice—with 50 pounds of explosive material in the head of the rocket, a single aircraft could launch a devastating attack. One of the most successful rockets of the war it came to be called the American HVAR (high-velocity aircraft rocket), a supersonic air-to-ground rocket unofficially coined “Holy Moses.” The P-51D Mustang could carry only three HVAR rockets under each wing, and the P-38 and P-47 five rockets under each wing. Though they required difficult precision aiming, HVAR rockets were capable of penetrating heavy armor and were thus more effective against the formidable German panzers than gun rounds.

Germany’s first air-to-air rocket was a derivative of the spin-stabilized 210 mm projectile used in ground artillery. A single rocket housed in a large tube launcher, it was used to attack heavy bombers at stand-off range. However, the weight of the launcher and rocket downgraded the aircraft’s performance. Germany began engineering a new rocket (designated R4M) specifically intended for multiple-launch attacks against bombers. (Later, the R4M was applied in air-to-ground attacks as well, but none were fielded in large numbers.) These were especially effective when all 24 rockets were launched at once, the effect being similar to that of a shotgun. Despite the fact that Germany had developed a very promising weapon in the R4M, the Luftwaffe’s attempts to outfit the Me 262A with rockets came late in the war, so few ever saw combat.

### USING ROCKETS

In an air-to-air rocket attack, aim exactly as you would while firing a gun. For ground attacks with rockets, the principles of aiming are similar to those described for glide-bombing ground targets — make a 30° or less dive, orient the nose toward the target, release the weapon, and pull out of the dive. The closer you are, the more likely your aim is to be true. The best approach, if you’re facing little or no flak fire, is to fly low and level, then make a gentle dive at a lower altitude when you’re ready to launch rockets.

- ★ Drop to below 1,000 feet (305 meters)
- ★ Fly near the intended target
- ★ Aim the nose toward the target and pitch down into a 30-degree or less dive
- ★ Fly straight toward the target and release the rockets
- ★ Pull out of dive

## STRAFING

Strafing is nothing more than a volley of bullets aimed specifically at ground targets. Machine gun and cannon rounds have difficulty penetrating heavily armored vehicles; strafing should realistically be preserved for use against transport vehicles and light personnel carriers.

You can strafe while diving, or while flying level at a very low altitude. If you choose to go low, take the extremely low road—the less altitude you have, the less time you'll spend in some ground gunner's sights. Dive strafing attacks are best applied to long targets, while low strafing attacks work well against smaller targets that are equally wide and long. Of course, you'll want to use whichever best suits your current position and combat situation.

To make a strafing attack from a dive, start your attack at about 5,000 feet (1525 meters), well to one side of the target and aligned along its length. Pitch the stick down to commence the dive. Keep an eye on the gunsight, and once you have the target in sight, let loose the bullets and start pulling out of the dive. Your inertia will disperse the stream bullets along the length of the target.

For a low strafing attack, go in below 300 feet (90 meters) of altitude and again position yourself off to one side of the target. You should be slightly beyond your gun's maximum range before you start the strafing run. Set the throttle to full speed and start firing as soon as you fly within your gun's maximum range. To spray your bullets slightly to either side, turn the rudder left and right as you're firing.

### DIVE STRAFING ATTACK

- ★ Drop to 5,000 feet (1525 meters) of altitude
- ★ Position yourself to one side of the target, aligned with its longest side
- ★ Pitch the nose down
- ★ When target is in your sights, fire
- ★ Pull out of the dive

### LOW STRAFING ATTACK

- ★ Start the approach below 300 feet (90 meters) and beyond maximum gun range
- ★ Throttle up to full speed
- ★ Fire as you come into gun range
- ★ Apply rudder to spray bullets from side to side

# CREDITS

## ENGINEERING

**Lead Engineer:** Ken Allen

**Engineering:** Cleve Cheng,  
Nicholas Fullager, Scott Gallardo,  
Yuji Higaki, Al Khorasani,  
Jason Micklewright, Brian Morgan,  
Dennis Ortiz, James Patrick

**Engineering Interns:** Kristin Higaki,  
Joe Kwan, Andy Taylor

## Additional Engineering:

Kirk MacLean, Ted Nguyen,  
Clay Welch, Steve Coallier

## ART

**Lead Artists:** Nick Corea, Chuck Eyler

**Aircraft:** Dave Mosher, Gary Martin,  
Ian House

**Terrain:** Steve Peterson, Ian House,  
Kent Brisley, Adrienne Cantfil,  
Brian Steffel, Richard Wong,  
Terry Fowler

**Ground Vehicles:** Ian House,  
Kent Brisley, John Brown

**User Interface:** Gary Martin,  
Steve Peterson

**Structures:** Steve Peterson,  
John Brown

**Museum:** Chuck Eyler, Jem Geylani

**Art Special Effects:** Chuck Eyler

**Illustrations:** Adrian Bourne

## DESIGN

**Campaign Design:** David Luoto

**Mission Design Lead:**  
Nathan Cummins

**Mission Designers:** Chris Bennett,  
Ron Lauron, Martin Johnson,  
Phil Engstrom

## PRODUCTION TEAM AND MANAGEMENT

### Project Management:

Beth Comstock

**Assistant Producers:** Phil Engstrom,  
John Williams

**Producer:** Steve Matulac

**Art Manager:** Terry Fowler

**Technical Director:** Nana Chambers

**V.P. of Technology and Programming:** Scott Cronce

**Executive in Charge of Production:** Paul Grace

## AUDIO PRODUCTION

**Audio Engineering:** Jim Sproul

**Audio Director:** Rob Hubbard

**Authentic Aviation Sounds Provided By:** Aircraft Records—Sonoma  
California, The Air Museum—Chino,  
California

**Music:** Don Veca

**Sound Effects:** Charles Stockley,  
Marc Foley

### Museum Curator Voice:

Jarion Monroe

**US Character Voices:** Tim Glenn,  
Toby Gleason, Michael Singer,  
Joe Shackel, Terry McGovern

### British Character Voices:

John Champion, Jarion Monroe,  
Roger L. Jackson, Toby Gleason

### German Character Voices (English):

Toby Gleason, Tim Glenn, Jarion  
Monroe, Roger L. Jackson,  
Terry McGovern

### German Character Voices (German):

Frank Röth, Kai Taschner, Nico  
Macoulis, Jacob Riedl,  
Manfred Trilling, Tobias Lelle

**VIDEO AND MEDIA PRODUCTION****Production Studio:** Digital Ranch**Video Producer:** Rob Lihani**Narrator:** Bill Ratner**Media Content Manager:**

David Luoto

**Aircraft Images Provided By:**Ghosts—Philip Makanna, Martinelli  
Photography, Smithsonian Institution**Additional Images Provided By:**

National Archives

**Consultation:** C.E. Bud Anderson**WWII FIGHTERS AND JANE'S  
INTRODUCTION SEQUENCES****Animation:** Chuck Eyler,

Jem Geylani

**Editing:** Michael Marsh**Sound:** Ken Felton**Music:** Don Veca**Jane's Intro:** Joel Symmes**Original Jane's Intro:** Paul Stankie**MARKETING/GAME MATERIALS****Product Marketing Manager:**

Patrick O'Laughlin

**Product Manager:** Jonathan Harris**Marketing Assistant:** David Bonacci**Media Relations:** Kirsten McEntire,

Jean Wong

**Manual:** Incan Monkey Gods Produc-  
tions—Tuesday Frase**Play Guide:** Yuri Hospodar**Documentation QA:** Jay Miller**Documentation Design/Layout:**

Corinne Mah

**TRANSLATIONS****Localization Manager:**

Atsuko Matsumoto

**Translation Liason:** David Luoto**German Translation:** Frank Dietz**TESTING****Testing Manager:** Kurt Hsu**Testing Lead:** Nathan Cummins**Testers:** Stormy Strong, Greg Garman,

James Grandt, Robert Walker,

Scott Parker

**QUALITY ASSURANCE****QA Supervisor:** Joel Knutson**QA Testers:** Jay Miller, Todd Manning,

Benjamin Crick, Jamil Dawsari,

Bobby Joe, Gabriel Gils Carbo

**Hardware Lab:** David Koerner,

Brian Winslow, Doug Chin

**SPECIAL THANKS**

Linda Smith—Jane's Information Group

Ltd., Brent Iverson, Richard Clark,

Norman Wong, Pat Silva, Mike

McCoy, 209th VFS Delta Hawks,

ToGo! Restaurant Delivery Service

## **NEED TECHNICAL SUPPORT?**

Please see the enclosed *Reference Card* for technical support information.

## **LIMITED WARRANTY**

Electronic Arts ("EA") warrants to the original purchaser of the computer software product, for a period of ninety (90) days from the date of original purchase (the "Warranty Period"), that under normal use, the media and the user documentation are free from defects in materials and workmanship.

### **WARRANTY CLAIMS**

To make a warranty claim under this limited warranty, please return the product to the point of purchase, accompanied by proof of purchase (i.e., purchase receipt), your name, your return address, and a statement of the defect. OR send the compact disc(s) to us at the address below within 90 days of purchase. Include a copy of the dated purchase receipt, your name, your return address, and a statement of the defect. EA or its authorized dealer will replace the product and return it to you (postage prepaid) or issue you with a credit equal to the purchase price.

**RETURNS WITHIN 90 DAY WARRANTY PERIOD**—To replace defective media within the 90-day warranty period, send the defective media, a copy of the original sales receipt, a return address, and a small note describing the difficulties you are experiencing to the address below. If the software media was damaged through misuse or accident, you will need to follow the returns after warranty policy detailed below.

**RETURNS AFTER WARRANTY**—To replace defective media after the 90-day warranty period has expired, send the original disc(s) to the address below. Enclose a statement of the defect, your name, your return address, and a check or money order for \$7.50 per replacement compact disc.

The foregoing states the purchaser's sole and exclusive remedy for any breach of warranty with respect to the software product.

Electronic Arts Customer Warranty  
P.O. Box 9025  
Redwood City, California 94065-9025

If you have warranty questions, you can also contact Customer Warranty via e-mail at [cswarranty@ea.com](mailto:cswarranty@ea.com) or by phone at (650) 628-1900.

### **LIMITATIONS**

This warranty is in lieu of all other warranties and no other representations or claims of any nature shall be binding on or obligate Electronic Arts. Any implied warranties applicable to this software product, including warranties of merchantability and fitness for a particular purpose, are limited to the ninety (90) day period described above. In no event will Electronic Arts be liable for any special, incidental, or consequential damages resulting from possession, use, or malfunction of this Electronic Arts software product.

Some states do not allow limitations as to how long an implied warranty lasts and/or exclusions or limitations of incidental or consequential damages so the above limitations and/or exclusions of liability may not apply to you. This warranty gives you specific rights, and you may also have other rights that vary from state to state.

**NOTICE**

Electronic Arts reserves the right to make improvements in the product described in this manual at any time and without notice.

This manual and the software described in this manual are copyrighted. All rights are reserved. No part of this manual or the described software may be copied, reproduced, translated, or reduced to any electronic medium or machine-readable form without the prior written consent of Electronic Arts, P.O. Box 9025, Redwood City, California 94065-9025, Attn: Customer Support.

Jane's is a registered trademark of Jane's Information Group Ltd. Reference work from Jane's Library © 1998 Jane's Information Group Ltd. All other trademarks are the property of their respective owners.

Janes's Combat Simulations is an Electronic Arts brand.

Electronic Arts and the Electronic Arts logo are trademarks or registered trademarks of Electronic Arts in the U.S. and/or other countries. All rights reserved.

Software and documentation © 1998 Electronic Arts. All rights reserved.

.....

# GET THE GUIDE, WIN THE WAR

## The Official Guide to *WWII Fighters*

It's 1944, and World War II is closing in on its do-or-die conclusion. For some, it's a last-ditch effort to keep the enemy

from overwhelming their forces. For others, it's their best chance to end the war and reclaim all they've lost.

For you, it's climbing into the cockpit and flying into the face of death. You know the odds are stacked against you.

You need all the help you can get if you're going to come back alive.



### **TACTICS AND TIPS –**

what to do and when to do it.



### **GAME MECHANICS AND STATISTICS –**

who you're up against ... and flying with.



### **MISSION ANALYSES –**

where the dangers are and how to deal with them.



Jane's® Combat Simulations is  
an Electronic Arts® brand

Available at your favorite software or book retailer  
or call 1-800-245-4525

Electronic Arts and ORIGIN are registered trademarks of Electronic Arts or its wholly-owned subsidiaries. All rights reserved. Jane's is a registered trademark of Jane's Information Group Ltd.